

PROJECT MANUAL AND SPECIFICATIONS

VOLUME II

For

Rappahannock Community College Renovation

Project Code: 260-17712

Glenns and Warsaw, Virginia
Permit Documents
May 11, 2010

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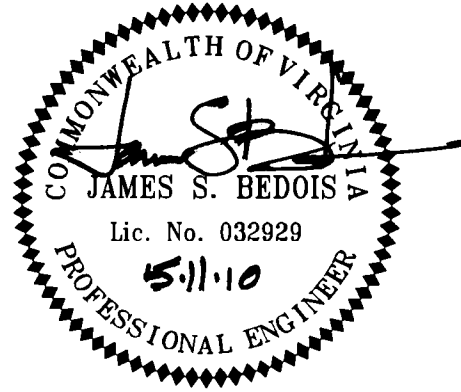
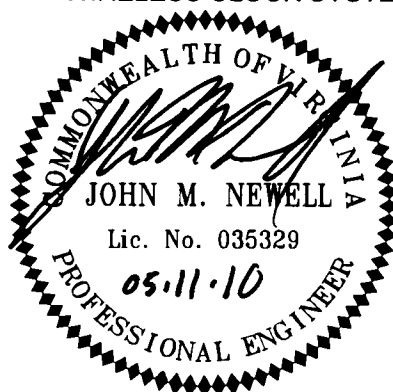
13930 WET-PIPE SPRINKLER SYSTEMS WITH FIRE PUMP

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SECTION 13930

WET-PIPE SPRINKLER SYSTEMS WITH FIRE PUMP

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and general provisions of contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to work of this section:

1.2 WORK INCLUDED

- A. Sprinkler System
- B. Fire Pumps and Controllers

1.3 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

- A. ANSI/NEMA MG 1 - Motors and Generators.
- B. ANSI/UL 448 - Pumps for Fire Protection Service.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volt Maximum).
- D. NFPA 13 - Installation of Sprinkler Systems.
- E. NFPA 20 - Installation of Centrifugal Fire Pumps.
- F. 2006 Virginia Uniform Statewide Building Code

1.4 GENERAL REQUIREMENTS: Section 15000, "Mechanical General Provisions", applies to this section, with the additions and modifications specified herein.

1.5 DESCRIPTION OF WORK: The work includes design and installation of a complete wet-pipe sprinkler complete with pumps, piping, fire department connections, valves, and fittings complete and ready for operation. Design and installation including equipment, materials, installation, workmanship, examination, inspection, testing shall be in accordance with the latest NFPA Standards except as modified herein.

1.6 SYSTEM DESCRIPTION

- A. System to provide coverage for entire building.
- B. Interface system with building fire and smoke alarm system.
- C. Provide system to NFPA 13 light, ordinary hazard occupancy requirements.
- D. Emergency Pressure System: Electric motor driven fire pump.
- E. Provide fire department connection as indicated.

1.7 RELATED WORK

- A. Section 15000, "Mechanical General Provisions".
- B. Section 16721, "Addressable Fire Detection & Alarm System".

1.8 QUALITY ASSURANCE

- A. Contractor's design and installation to conform to NFPA 13 and NFPA 20.
- B. Equipment and Components: Bear UL, FM label or marking.
- C. Welding Materials and Procedures: Conform to ASME Code. Conform to NFPA 20 for Fire Pump Installation and NFPA 13-2007.
- D. Valves: Bear UL, FM label or marking. Provide manufacturer's name and pressure rating marked on valve body. Valves shall be approved for the intended use. Valves of similar type shall be of same manufacturer.
- E. Provide pumps with manufacturer's name, model number, and rating/ capacity.
- F. Test pump, driver, and controller in accordance with NFPA 20.

1.9 REGULATORY REQUIREMENTS

- A. Contractor shall submit shop drawings to the A/E only for approval. Once approved by A/E, shop drawings shall be forwarded for review and approval by authority having jurisdiction. Shop drawings shall include the following: Hydraulic Calculations, Product Data, Shop Drawings, and Low Water Pressure Cut-in Controller.

1.10 SUBMITTALS

- A. Comply with Section 15000, MECHANICAL GENERAL PROVISIONS.
- B. Submit shop drawings and product data under provisions of 15000 MECHANICAL GENERAL PROVISIONS to the A/E. Contract Drawings (Bid Documents) are to show intention. The sprinkler shop drawings shall comply with NFPA 13, 2007. Obtain review under 1.9A, prior to purchase and installation.
- C. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, components and accessories.
- D. Indicate pump type, capacity, power requirements, affected adjacent construction.
- E. Submit certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
- F. Prior to submittal of shop drawings for technical review and approval by the authority having jurisdiction, City or County Fire Marshall, submit sprinkler head arrangement/locations to Architect/Engineer only for approval.

- G. Shop drawings to include space names, numbers and ceiling elevations including those created by soffits, bulk heads, clouds, etc.

1.11 OPERATION AND MAINTENANCE DATA

- A. Submit manufacturer's operation and maintenance data as required.
- B. Include written maintenance data on components of system, servicing requirements, and Record Drawings.
- C. Include pump operation, maintenance, and inspection data, replacement part numbers and availability, and location and numbers of service depot.

1.12 EXTRA STOCK

- A. Provide extra sprinkler heads under provisions of NFPA 13.
- B. Provide suitable wrenches for each head type.
- C. Provide metal storage cabinet in location designated.
- D. Provide one set of gaskets for each pump type and model supplied for Owner's use.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Steel Pipe: ASTM A53; ASTM A120; black; galvanized.
- B. Copper Tube: ASTM B75; B88; drawn, seamless.
- C. Iron Pipe: ANSI/AWWA C151, ductile iron.

2.2 PIPE FITTINGS

- A. Steel Fittings: ANSI/ASME B16.9, wrought steel, butt welded, ANSI/ASME B16.25, butt weld ends, ASTM A234, wrought carbon steel and alloy steel, ANSI/ASME B16.5, steel flanges and fittings, ANSI/ASME B16.11, forged steel socket welded and threaded.
- B. Cast Iron Fittings: ANSI/ASME B16.1, flanges and fittings, B16.4, screwed fittings.
- C. Malleable Iron Fittings: ANSI/ASME B16.3, screwed type.
- D. Copper Fittings: ANSI/ASME B16.18, cast bronze, solder joint, pressure, B16.22, wrought copper and bronze, solder joint, pressure type.
- E. Ductile Iron Fittings: ANSI/AWWA C110.

2.3 JOINT MATERIALS

- A. Solder: ANSI/ASTM B32, 95/5 alloy.
- B. Brazing: ANSI/AWS A5.8.

2.4 PIPING SPECIALTIES

- A. Automatic Sprinkler Valve: Flow detector with alarm circuits, pressure switch, pressure retard chamber.
- B. Alarm Gong: Electric Type.
- C. Fire Department Connection: Wall mounted type; brass; chrome plated finish; thread size to suit fire department hardware; two way threaded dust cap and chain of same material and finish, 3/4 inch automatic drip marked "Sprinkler - Fire Department Connection".
- D. Valve cabinets: 20 gauge white enamel coated steel box to accommodate 2-1/2" fire department valve. Potter Roemer 1810 or approved equal.

2.5 SPRINKLER HEADS

- A. Suspended Ceiling Type: Quick response recessed pendent type with chrome plated finish, with matching escutcheon.
- B. Exposed Area Type: Quick response standard upright type with brass chrome plated finish.
- C. Fusible Link: Temperature rated for specific area hazard.
- D. Sprinklers utilizing 'O' rings are prohibited.
- E. Flexible sprinkler heads shall be U.L. listed under Category VENF.

2.6 GATE VALVES

- A. Bronze, rising stem, inside screw, solid wedge, manufactured by Grinnell, Stockham, Jenkins.
- B. Iron body, bronze trim, rising stem, OS&Y, solid wedge, manufactured by Nibco, Stockham, Jenkins.

2.7 CHECK VALVES

- A. Bronze, swing disc, manufactured by Grinnell, Stockham, Jenkins.
- B. Iron body, bronze trim, swing disc, renewable disc and seat, manufactured by Grinnell, Stockham, Jenkins.
- C. Iron body, bronze trim spring loaded, renewable composition disc, manufactured by Grinnell, Stockham, Jenkins.

2.8 CENTRIFUGAL FIRE PUMPS

- A. Acceptable Manufacturers - Horizontal Centrifugal Pumps:
 - 1. Allis-Chalmers Pumps.

2. Patterson Pumps.
 3. Reddy-Bufferaloes Pumps.
- B. Furnish and install as shown on plans, one Patterson Fire Pump system, complete with pump, driver, controller and accessories. The Fire Pump shall be designed to deliver 375 gpm when operating against at TDH as shown below. The pump shall also deliver not less than 150% of rated capacity at a pressure not less than 65% of rated pressure. The shut off pressure shall not exceed 120% of rated pressure. Minimum suction pressure is 20 psig.

DESIGN POINTS

gpm HD Requirement

0 59 psi Max
375 50 psi Min (UL/FM Label)
600 40 psi Min

1. The Fire Pump shall be a Armstrong (or acceptable manufacturer listed in 2.8 A) Model F4516 Horizontal split case, bronze fitted, single stage, double suction, centrifugal pump, vertically mounted with bronze shaft sleeves, cast wear rings and packed stuffing boxes with lantern rings, case iron casing with 150# discharge flange. Pump shall be listed by Underwriters' Laboratories, Inc. and approved by Associated Factory Mutual. The pumping unit shall meet all requirements of the National Fire Protection Association Pamphlet #20 (latest edition). Pump seals, casing and flanges shall be good for 250 psig working pressure.
2. The pumping unit shall include the following accessories:
Automatic air release valve.
Circulation relief valve.
Suction and discharge pressure gauges.
Outside hose valve manifold with hose valves, caps and chains (hose valve threads to match local fire department standards).
Eccentric suction reducer.
Concentric discharge increaser.
Pump coupler guard.
3. The drive shall be HP rated as scheduled on the drawings, vertical, plate mounted ODP ball bearing type AC induction squirrel cage motor; wound for voltage and phase as scheduled on the drawings, 60 cycle, a.c. operation. Locked rotor current shall not exceed the value specified in NFPA Pamphlet #20.
4. The fire pump motor control shall be completely assembled, wired and tested by the manufacturer before shipment from the factory, and shall be marked "Fire Pump Controller". The controller shall be located as close as practical and within sight of the motor.
5. The controller shall be so located or protected that it will not be injured by water escaping from the pump or connections. The controller shall be of the across-the-line type for motors rated 20 HP or less, and electronic solid static type soft start for motors larger than 20 HP, and shall be complete with externally operable disconnect switch circuit breaker with an interrupting capacity as indicated on the electrical drawings, pressure switch, pilot lamp to indicate circuit breaker is closed

and power available, ammeter test link and volt meter test studs and a two position selector switch marked "Automatic and Non-Automatic". Necessary contacts and relays shall be provided to actuate alarm circuits indicating pump operation and power failure at controller. If the pump is required to be provided with standby power, provide a combination motor controller/automatic transfer switch assembly. Coordinate with the electrical drawings. Controller shall be a fully equal to Firetrol model FTA with externally operable pressure setter and indicator.

6. The pump, drive, controller, transfer switch (if required) and all accessories shall be purchased under a unit contract. The pump shall be given a complete performance test with positive suction pressure. Certified performance curves for both conditions shall be prepared and submitted for approval prior to shipment. Pump shall also be hydrostatically tested to twice the shut-off pressure but in no case less than 250 lbs. per square inch.
7. The pump manufacturer shall assume responsibility to provide the services of a factory-trained engineer to supervise installation and to be available to conduct final field acceptance test. The fire pump shall be set to start automatically on a fall of pressure to (as required by approving authority) psig and to be manually stopped.

2.9 JOCKEY PUMPS

A. Acceptable Manufacturers:

1. Armstrong Pumps.
2. Taco Pumps.
3. Grundfos Pumps.

- B. The contractor shall furnish and install in location as shown on the plans a Armstrong fire jockey pump with bronze fitted construction. The pump shall have a capacity of 10 gpm at 70 psig TDH. The pump is to be furnished with case wear rings and mechanical seal with all metal parts to be 316 SS, Buna-N bellows, Ni-Resist seat and carbon washer. The pump is to be close-coupled to a 60 cycle, a.c. and ODP electric motor as scheduled on the drawings with stainless steel motor shaft. Jockey Pump shall be suitable for 250 psig working pressure and supplied with casing relief valve.

- C. The jockey pump shall be supplied complete with a wall mounted factory-wired and tested jockey pump controller. Panel assembly shall be rated for the available fault current indicated on the electrical drawings. The unit shall be suitable for operation on 60 cycle, a.c. as scheduled on the drawings and shall be of the automatic across-the-line type complete with pressure switch, magnetic motor starter, door interlock and hand-off automatic selector switch and pump running light. Jockey pump shall be arranged to start and stop automatically.

2.10 BACKFLOW PREVENTER

- A. Reduced Pressure Backflow Preventers: Provide UL listed for fire service and ASSE 1013 approved reduced pressure backflow preventers where indicated, as manufactured by Watts 900 Series, or equal by Febco or Conbraco. Provide strainer with blow down

valve upstream of device in accordance with manufacturer's recommendations. Provide with air gap fitting piped to nearest floor drain or other approved location.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate work of this Section with other affected work.

3.2 INSTALLATION - PIPING

- A. Connect wet sprinkler system to water source as required.
- B. Locate fire department connection with sufficient clearance from walls, buildings, obstructions, or adjacent siamese connectors to allow full swing of fire department wrench handle, and within maximum required distance from fire hydrants.
- C. Locate outside alarm gong on building wall.
- D. Place pipe runs to minimize obstruction to other work.
- E. Place piping in concealed spaces above finished ceilings.
- F. Center heads in ceiling tile, provide piping offsets as required.
- G. Apply strippable tape or paper cover to ensure concealed sprinkler head cover plates do not receive field paint finish.
- H. Ream pipe and tube ends to full inside diameter.
- I. Remove burrs and bevel plain end ferrous pipe.
- J. Remove scale and foreign material, inside and outside, before assembly.
- K. Die cut screw joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.
- L. Coat threaded ends with pipe lubricant compound.
- M. Install piping in accordance with NFPA 13 for sprinkler systems and NFPA 20 for fire pumps.
- N. Do not penetrate building structural members unless indicated.
- O. Provide sleeves when penetrating floors and walls.
- P. Seal pipe and sleeve penetration to achieve fire resistance equivalent to fire separation required.
- Q. Install flexible heads per manufacturer instructions and according to the most recent UL listing.

3.3 INSTALLATION - PUMP

- A. Pipe drain from pump bases, pump stuffing boxes, and pump casings to floor drains.
- B. Provide air vent valves on pump cases.
- C. Use long radius elbows on suction side of pump.
- D. Do not support piping from pump casing.
- E. Align base mounted pumps.

3.4 INSTALLATION - VALVES

- A. Install valves with stems upright or horizontal, not inverted.
- B. Provide gate valves for shut-off or zone isolating service.
- C. Provide drain valves at main shut-off valves, low points of piping and apparatus.
- D. Provide supervision for valves as required.

3.5 CLEANING

- A. Flush entire piping system of foreign matter.

3.6 SYSTEM TESTS

- A. Hydrostatically test entire system, per NFPA 13 and 20.
- B. Test shall be witnessed by authority having jurisdiction.
- C. Provide pump, fittings, and controls complete in accordance with National Fire Codes Standard No. 20 "Centrifugal Fire Pumps" to meet requirements of the 2006 VUSBC Building Code. The pump manufacturer shall provide all accessories and attachments. The pump manufacturer shall provide installation instructions, and supervise start-up, final adjustment, and testing of the system. Unit shall bear UL/FM seal of approvals for the specified conditions.
- D. Provide all piping and accessories including temporary pumping equipment to provide system protection during construction as directed by the City or County Building Officials and Fire Marshall.
- E. Contractor shall provide third party verification for installation of suspended ceiling rails meeting ASTM C635 and installation method meeting ASTM C636. Third party verification shall provide certificate that all standards were met. Third party verification shall be by an approved, independent special inspector for compliance with the most recent listing requirements and manufacturer's installation instructions.

END OF WET-PIPE SPRINKLER SYSTEMS WITH FIRE PUMP

SECTION 15000
MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The General Conditions, Supplementary General Conditions, and Special Conditions of this Contract form a part of this Division of Specification.
- B. This section forms a part of all sections under Division 15 Mechanical.
- C. Requirements herein augment or clarify articles specified under aforementioned General and Special Conditions.

1.2 SITE EXAMINATION

- A. Before submitting bid, Contractor shall examine the premises and satisfy himself as to the existing conditions under which he will be obliged to operate or what will affect the work under this Contract. Contractor shall report to the Architect any condition which might prevent installation of equipment or systems in the manner intended. No allowance will be made subsequently in this connection in behalf of this Contractor for error or negligence on his part.

1.3 CODES AND STANDARDS

- A. Latest effective publications of applicable codes and ordinances of local governing agencies and of the following standards, codes, etc., as they apply, form part of these specifications as if were written fully herein. The publication date is the publication in effect as of the bid date, except when a specific publication date is listed. These will be referred to throughout in abbreviated form.

- 1. Virginia Uniform Statewide Building Code (VUSBC)
- 2. National Fire Protection Association (NFPA)
- 3. Factory Mutual Engineering Association (FM)
- 4. Underwriters' Laboratories, Inc. (UL)
- 5. Occupational Safety and Health Administration (OSHA)
- 6. American Society of Mechanical Engineers (ASME)
- 7. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
- 8. Air Conditioning and Refrigeration Institute (ARI)
- 9. American National Standards Institute (ANSI)
- 10. American Society for Testing and Materials (ASTM)

11. Health Care Facilities Handbook
12. American Welding Society (AWS)
13. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
14. Air Movement and Control Association, Inc. (AMCA)
15. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA)
16. American Gas Association (AGA)
17. Electrical Testing Laboratories (ETL)
18. Americans with Disabilities Act (ADA)
19. International Mechanical Code
20. International Plumbing Code

1.4 PERMITS, INSPECTIONS, FEES AND NOTICES

- A. Unless modified by the General Conditions and Supplementary Conditions, work is to be executed and inspected in accordance with governing codes, laws, ordinances, rules, and regulations applicable to particular class of work, and fees in connection therewith are to be paid by this Contractor.
- B. This Contractor is to arrange for project inspection, paying charges pertaining hereto. He shall give the proper authority requisite notice relating to work under his charge, shall afford Architect and authorized inspectors every facility for inspection and shall be responsible for violations of law. Upon completion of work, he shall have work inspected, if required, obtaining certificate of inspection and approval from inspecting agency, and shall deliver such certificate to Architect.

1.5 SCOPE OF WORK

- A. Work required for Division 15 Mechanical shall include labor, materials, equipment, appurtenances, and services to provide first class working systems, tested and ready for operation. Installation shall conform to the drawings and specifications, incorporating the best standards of workmanship. Materials shall be new and of good quality, and labor shall be performed by skilled mechanics under the direction of a competent superintendent.

1.6 DRAWINGS AND SPECIFICATIONS

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable mechanical systems complete in every respect.
- B. Apparatus, appliance, material or work not shown on drawings but mentioned in the specifications, or vice versa, or incidental accessories necessary to make the work

complete and ready for operation, even if not particularly specified, shall be provided by the Contractor without additional expense to the Owner.

- C. Contractor shall examine and consult drawings and specifications of other trades to better familiarize himself with the character of construction and include in his bid work of his trade shown or reasonably inferred. He shall consult the drawings and specifications of other trades in installing his work.
- D. This Contractor shall be thoroughly familiar with specified products relating to his work and shall submit written objections prior to bid if he objects to the proposed use of any product.
- E. Should structural difficulties prevent the installation of piping, ductwork, fixtures, or equipment at the points shown on the drawings, necessary deviations therefrom, as determined by the Architect, will be permitted and shall be made without additional cost. This Contractor shall work with other Contractors and arrange his work so as not to interfere with the work of other Contractors.
- F. Drawings are diagrammatic, intending to show general arrangement and location of system components, with no attempt made to show every ell, tee, fitting, etc. Due to the small scale of the drawings, and to unforeseen job conditions, required offsets and fittings may not be shown but shall be provided at no change in Contract price. Ducts and pipes shall be run in spaces indicated as job conditions warrant, arranged for most convenient access for servicing, with due consideration given to swing joints and to other Contractor's work. If departures from the contract drawings are deemed necessary, Contractor shall submit details of such departures and the reasons therefor as soon as practicable after award of contract to the Architect for approval. Make no such departures without prior written approval of the Architect.
- G. Contractor shall maintain on site a current set of drawings and specifications.
- H. In case of conflicting information on the drawings and/or in the specifications, the proper interpretation shall be made by the Architect.
- I. Disagreements occurring between trades covering various phases of the work shall be referred to General Contractor for decision.
- J. Changes and additions to scope of the work under this contract shall be submitted to the Architect and his written approval obtained before proceeding with the changed work.

1.7 WORDING

- A. Specifications are of simplified form and include incomplete sentences. Omission of words or phrases such as "the Contractor shall", "shall be", "provide", "furnish", "a", "an", "the" is intentional. Omitted words or phrases shall be supplied by inference.

1.8 DEFINITIONS

- A. "Provide": To furnish, erect, install, and connect up complete and ready for regular operation, particular work referred to, unless specifically indicated or specified otherwise.
- B. "Work": Labor and materials, or both, including apparatus, controls, accessories, and other items necessary or required to provide a complete installation.

- C. "Piping": Pipe and fittings, flanges, valves, controls, hangers, traps, drains, insulation, and items necessary or required in connection with or relating to such piping to provide a complete installation.
- D. "Concealed": Embedded in masonry or other construction, installed behind wall furring, within double partitions or above hung ceilings, in trenches, tunnels, or crawl spaces.
- E. "Exposed": Not installed underground or "concealed" as defined above.
- F. "Indicated" or "Shown": As indicated or shown on drawings.
- G. "Noted": As indicated on drawings and/or specified.
- H. "Contract" or "this Contract" shall consist of documents listed in the Contractor Agreement and Supplemental Agreements, data or drawings which could reasonably be required to complete the work. This shall be considered as one instrument and referred to collectively as the "Contract Documents".
- I. Whenever the words "as shown" or "indicated" are used in the description of any part of the work, it shall be understood to mean as shown on the contract drawings, unless another meaning is plainly indicated or noted.

1.9 SUBMITTALS

- A. Products List:
 - 1. Within 15 days after Contract Award Date, submit to Architect a complete list of major products proposed to be used, with the name, address, and phone number of the manufacturer, manufacturer's representative, and the installing subcontractor. List shall include the following:
 - a. Rooftop Unit
- B. Submit Shop Drawings, Product Data and Samples within thirty (30) days of award of contract and in accordance with the General Conditions and Supplementary Conditions. All interdependent equipment, i.e., chillers, boilers, pumps and associated hydronic equipment, shall be submitted simultaneously. Submittals are required for items provided under this specification. Review of submittals by the Architect and associated action taken by the Architect does not relieve the contractor of requirements set forth by the contract documents.
- C. Submittals shall clearly indicate all features, options, capacities, etc. to show compliance with the drawings and specifications.
- D. The Contractor Shall:
 - 1. Coordinate submittal with requirements of the work and of the Contract Documents.
 - 2. Notify the Architect in writing, at time of submission, of deviations in the submittals from requirements of the Contract Documents.
 - 3. Begin no fabrication or work which requires submittals until return of submittals with Architect approval.

4. Make submittals promptly and in such sequence as to cause no delay in the work or in the work of other contractors.
- E. Drawings prepared by the Contractor, for the Contractor's use, shall be submitted for review. Such drawings include, but are not limited to: duct fabrication and layout drawings, fire protection piping and layout drawings, equipment layout drawings, coordination drawings, and drawings of miscellaneous details.
- F. Prepare Product Data as Follows:
 1. Clearly mark each copy to identify pertinent products or models.
 2. Show performance characteristics and capacities.
 3. Show dimensions and clearances required.
 4. Show wiring diagrams, piping diagrams and controls.
- G. Prepare manufacturer's standard schematic drawings and diagrams as follows:
 1. Modify drawings and diagrams to delete information which is not applicable to the work.
 2. Supplement standard information to provide information specifically applicable to the work.
- H. Prepare office samples of sufficient size and quantity to clearly illustrate:
 1. Functional characteristics of the product, with integrally related parts and attachment devices.
 2. Full range of color, texture and pattern.
- I. Submittals shall contain:
 1. The date of submission and of any previous submissions.
 2. The project title and number.
 3. Contract or project identification.
 4. The names of:
 - a. Contractor.
 - b. Supplier.
 - c. Manufacturer.
 5. Identification of the product, and specification section.
 6. Field dimensions, clearly identified as such.

7. Relation to adjacent or critical features or materials.
 8. Applicable standards.
 9. Identification of deviations from Contract Documents.
 10. Identification of non-complying features and reason for the non-compliance. The reason shall be specific in nature.
 11. Identification of revisions on resubmittals.
 12. Contractor's stamp, initialed or signed, certifying to review of submittal, verification of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.
- J. Submittals of Mechanical and Plumbing Equipment requiring maintenance shall be accompanied by three (3) sets of the manufacturers' standard Operating and Maintenance Instructions and Parts Lists. A bound manual with an index and identification tabs shall be prepared for each set. These are to be retained by Contractor, until completion of job, at which time they will be assembled and turned over to the Architect.

1.10 MANUFACTURER'S INSTRUCTIONS

- A. When Contract Documents require that installation of work shall comply with manufacturer's printed instructions, obtain and distribute copies of such instructions to parties involved in the installation, including two copies to Architect.
1. Maintain one set of complete instructions at the job site during installation and until completion.
- B. Handle, install, connect, clean, condition and adjust products in strict accordance with such instructions and in conformity with specified requirements.
1. Perform work in accordance with manufacturer's instructions. Do not omit any preparatory steps or installation procedure unless specifically modified or exempted by Contract Documents.
 2. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with Architect for further instructions.
 3. Do not proceed with work without clear instructions.

1.11 ADDITIONAL REQUIREMENTS

- A. All equipment and appliances that comprise part of the building mechanical systems regulated by the International Mechanical Code shall be listed and labeled in accordance with the International Mechanical Code.
- B. All listed and labeled equipment shall be installed in accordance with its listing label, manufacturer's installation instructions, and the International Mechanical Code.

- C. Manufacturer's installation instructions shall be available at the job site for use and inspection.

PART 2 - PRODUCTS

2.1 MANUFACTURING STANDARDS

- A. Materials shall be new and designed and/or constructed for their intended use and application. Defective equipment or equipment damaged in the course of installation or test shall be replaced or repaired in a manner meeting the approval of the Architect. Materials to be furnished under this specification shall be the standard products of manufacturers regularly engaged in the production of such equipment and shall be the manufacturer's latest standard design. All items of the same type and rating shall be identical.

2.2 ELECTRICAL REQUIREMENTS

- A. Except as otherwise detailed or specified, all interconnecting power wiring required to operate electrical devices and equipment furnished in this Division will be provided under Division 16 Electrical.
- B. All controllers, motors, starters, and individual component fusible protection for all accessory equipment in accordance with NEC, etc. shall be as specified under Division 16 Electrical of the specifications and furnished with equipment under this division. Starters and controllers that are not mounted on the equipment shall be turned over to the Electrical Contractor for installation.
- C. Disconnect switches shall be provided under Division 16 Electrical unless specified in Division 15 Mechanical as integral with equipment.
- D. Requirements for electrical apparatus, devices, controls, etc. furnished in this Division shall conform to Division 16 Electrical.
- E. Control and interlock, wiring and conduit required for electrical devices and equipment furnished in this Division will be provided under this division.

2.3 MOTORS AND MOTOR CONTROLS

- A. All motors furnished as a part of the work of this Division, unless otherwise specified, shall be furnished by the manufacturer of the equipment served and shall be mounted and aligned so as to run free and true.
- B. All motors shall be provided with a terminal box of adequate size to accommodate the required conduit and wiring. Wire nuts and lugs will be provided under Division 16 Electrical.

PART 3 - EXECUTION

3.1 SCHEDULE OF WORK

- A. The schedule of the mechanical work shall be arranged to suit the progress of work by the other trades and shall in no way retard progress of construction of the building.
- B. Work under this Division shall proceed in advance of the work of others whenever possible, eliminating cutting and patching. When such procedure is impossible, cutting and patching shall be done in an approved manner. Cutting shall not endanger structural function of the building. Patching shall match existing work. Actual work of cutting and patching of existing surfaces shall be performed by the subcontractor who originally prepared these surfaces, e.g., cutting and patching of masonry wall will be performed by the masonry subcontractor. Cutting shall be carefully done and damage to building, piping, wiring or equipment as a result of cutting shall be repaired by skilled mechanics of trade involved. Each Contractor shall furnish sketches showing locations and sizes of all openings, chases, etc. required for installation of his work.
- C. Contractor shall furnish and locate sleeves and inserts required before floors and walls are built. Contractor shall coordinate all drilling required for installation of his hangers.
- D. Exposed piping and ductwork shall be completely installed and ready for painting by General Contractor. Any incorrect and added work installed by Mechanical Contractor after the General Contractor has painted the areas shall be painted at no additional cost to the Owner.
- E. Contractor must cooperate completely with contractors providing equipment under other divisions of the specifications. This is particularly important in accordance with Division 16 Electrical.
- F. Space Priority:
 - 1. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
 - a. Gravity flow piping systems.
 - b. Vent piping systems.
 - c. Ceiling recessed lighting fixtures.
 - d. Concealed air terminal units, fans.
 - e. Air duct systems.
 - f. Sprinkler systems piping.
 - g. Forced flow piping systems.
 - h. Electrical conduit, wiring, control wiring.

2. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
3. Change in order of priority is permissible by mutual agreement of all affected trades.
4. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the Contractor for the affected trade.
5. The work of a particular trade shall not obstruct access for installation, operation and maintenance of the work, materials and equipment of another trade.

G. Installation

1. Inaccessible Equipment:
 - a. Where the end user determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the end user.
 - b. The term "conveniently accessible" is defined as capable of being reached without the use of ladders 2'-0" greater than the ceiling height, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork. Equipment above ceilings shall be within 12" of top of ceiling.

3.2 BUILDING OPENINGS FOR ADMISSION OF EQUIPMENT

- A. Contractor shall ascertain from his examination of the architectural and structural drawings whether any special temporary openings in the building for the admission of apparatus furnished under this Contract will be necessary, and he shall notify the Architect accordingly. Failure to give this notification in sufficient time for Architect to arrange for same during construction shall not incur any additional cost to the Owner.

3.3 WORK IN EXISTING BUILDINGS

- A. Work in existing buildings must be scheduled during times when the buildings are occupied. Systems serving the existing buildings must be kept operative at all times. Temporary system shutdown shall be approved by the Owner prior to actual shutdown.
- B. Fixtures, equipment, piping, etc. that are removed and not indicated "to be reused" are to become property of the Contractor and shall be removed from the building site.
- C. Demolition drawings indicate approximate location, size and quantity of piping: Minor variations in location of piping exposed by removal of walls or openings in walls and required to maintain an operating system shall be relocated as directed at no additional expense to the Owner. Piping not required to maintain an operating system shall be removed. The Mechanical Contractor shall be responsible for the piping work involved in cutting required for all trades.
- D. Cutting and patching will be performed by the General Contractor. Contractor shall furnish sketches showing locations, and sizes of openings, chases, etc. required for installation of his work.

3.4 STORAGE AND PROTECTION

- A. Work, fixtures, equipment, and materials shall be protected at all times. The Contractor shall make good damage caused, whether directly or indirectly, by the workmen. Work shall be properly protected to prevent destruction or damage. Pipe and ductwork openings shall be closed with caps and plugs or plastic sheeting during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemical, and mechanical injury.
- B. Store products in accordance with manufacturer's instructions, with seals and labels intact and legible.
 - 1. Store products subject to damage by the elements in weathertight enclosures.
 - 2. Maintain temperature and humidity within the ranges required by manufacturer's instructions.
- C. Exterior Storage:
 - 1. Store fabricated products above the ground, on blocking or skids, prevent soiling or staining. Cover products which are subject to deterioration with impervious sheet coverings, provide adequate ventilation to avoid condensation.
- D. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to assure that products are maintained under specified conditions, and free from damage or deterioration.
- E. Protection After Installation:
 - 1. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.

3.5 TRANSPORTATION AND HANDLING

- A. Arrange deliveries of products in accordance with construction schedules, coordinate to avoid conflict with work and conditions at the site.
 - 1. Deliver products in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.
 - 2. Immediately on delivery, inspect shipments to assure compliance with requirements of Contract Documents and approved submittals, and that products are properly protected and undamaged.
- B. Provide equipment and personnel to handle products by methods to prevent soiling or damage to products or packaging.

3.6 CLEANING

- A. Contractor shall be responsible for keeping the premises free of shipping cartons, crates, material scrap, pipe cuttings, etc. related to his work. Floors shall be protected with leakproof pans where pipe cutting or threading operations are in progress.

- B. Prime coated equipment, insulation, piping, and pipe covering shall be left dust-free where painting is not required. Thorough cleaning shall be done where painting is required.
- C. Factory finished painted equipment shall be washed with mild soap and water and left in first class condition, entirely free of stains or streaks. Abrasive materials shall not be used.
- D. Plumbing fixtures shall be cleaned with mild soap and water containing a disinfecting agent. Trim handles shall be set at same angle and trim shall be polished. Aerators shall be removed, cleaned and reinstalled after piping has been cleaned and disinfected. Pop-up wastes shall be checked for proper operation.
- E. Sumps, pits, trenches, manholes, catch basins, and floor drains shall be cleaned and left free of foreign material.

3.7 ELECTRICAL REQUIREMENTS

- A. Except as otherwise detailed or specified, all electrical devices, apparatus, etc., furnished in this Division, but which are not integral with the equipment served, will be installed under Division 16 Electrical.

3.8 EQUIPMENT CONNECTIONS

- A. Contractor shall connect equipment and/or fixtures requiring piping or plumbing connections.
- B. Equipment not particularly specified in this Division of the specification is either specified under other Divisions of these specifications, or furnished by the Owner: Plumbing work in connection therewith is to be included under this Division unless otherwise indicated. Contractor shall carefully examine drawings and other Divisions of the specifications and shall provide roughing-in, including traps, to connect this equipment to the piping or plumbing system, and leave ready for use and operation, with stops, supplies, etc.
- C. Connections to equipment shall be in accordance with shop drawings to be furnished by the equipment supplier.

3.9 SYSTEM START-UP

- A. Provide material and labor required to perform start-up of equipment and system prior to beginning of test, adjust and balance procedures.
- B. Plumbing, air conditioning, heating, and ventilating system shall be operated separately, or in conjunction with the other, for a sufficient period of time to demonstrate to satisfaction of the Architect the ability of the system to meet capacity and performance requirements while maintaining design conditions, in accordance with the true intent and purpose of these specifications. Contractor shall set and adjust mechanical and control equipment, appurtenances and other items as necessary to properly balance phases of the system and shall have the system operating and maintaining design temperature, humidity, and air circulation throughout the building. Contractor shall provide additional fan sheaves or pump impellers required to obtain design flow rates.

C. Design Conditions:

		INDOOR (deg. F)	OUTDOOR (deg. F)
1.	Occupied Cooling	72	94
2.	Occupied Heating	70	17
3.	Unoccupied Heating	67	17
4.	Night Setback – Cooling	78	94
5.	Night Setback – Heating	67	17

D. Prior to start of balancing, this Contractor shall review balancing test procedures with the Architect. Contractor shall provide information and assistance as required in cooperation with the test, adjust and balance service.

E. Start-up procedures shall be as follows:

1. Bearings:

- a. Inspect for cleanliness, clean and remove foreign materials.
- b. Verify alignment.
- c. Replace defective bearings, and those which run rough or noisy.
- d. Lubricate as necessary, and in accordance with manufacturer's recommendations.

2. Drives:

- a. Adjust tension in V-belt drives, and adjust varipitch sheaves and drives for proper equipment speed.
- b. Adjust drives for alignment of sheaves and V-belts.
- c. Clean, remove foreign materials before starting operation.

3. Motors:

- a. Check motor for amperage comparison to nameplate value.
- b. Correct conditions which produce excessive current flow, and which exist due to equipment malfunction.
- c. Verify rotation and direction of driven equipment is in accordance with design.

4. Valves:

- a. Inspect both hand and automatic control valves, clean bonnets and stems.

- b. Tighten packing glands to assure no leakage, but permit valve stems to operate without galling.
 - c. Replace packing in valves to retain maximum adjustment after system is judged complete.
 - d. Replace packing on any valve which continues to leak.
 - e. Remove and repair bonnets which leak.
 - 5. Verify that control valve seats are free from foreign material, and are properly positioned for intended service.
 - 6. Tighten flanges after system has been placed in operation. Replace flange gaskets which show any sign of leakage after tightening.
 - 7. Inspect screwed and welded joints for leakage. Promptly remake joints which appears to be faulty, do not wait for rust to form. Clean threads on both parts, apply compound and remake joints.
 - 8. After system has been placed in operation, clean strainers, dirt pockets, orifices, valve seats and headers in fluid systems, to assure being free of foreign materials.
 - 9. Remove rust, scale and foreign materials from equipment and renew defaced surfaces.
 - 10. Set and calibrate draft gauges of air filters and other equipment.
 - 11. Inspect fan wheels for rotation, clearance and balance. Provide factory-authorized personnel for adjustment when needed.
 - 12. Check electrical control circuit to assure that operation complies with specifications and requirements to provide desired performance.
 - 13. Inspect pressure gauges and thermometers for calibration. Replace items which are defaced, broken, or which read incorrectly.
 - 14. Repair damaged insulation.
 - 15. Vent gasses trapped in hydronic systems.
 - 16. Verify that liquids are drained from gas or air systems.
- F. Provide such periodic continuing adjustment services as necessary to insure proper functioning of mechanical systems after occupancy of the project, and for a period of one year after date of substantial completion.

3.10 COMPLETION OF WORK

A. Plumbing Fixture Caulking:

1. Where irregular walls cause gaps between fixture and wall, Contractor shall fill voids by caulking around fixture.

B. Operating Instructions:

1. Printed instructions, installed in suitable frame with glass front which covers operating and maintenance of each major item of equipment, shall be posted at locations designated by Architect. Bound manuals for equipment operating and maintenance instructions and parts lists shall be turned over to the Owner. Contractor shall carefully instruct Owner's operation man during adjustment and testing period of equipment for each length of time as may be necessary to thoroughly familiarize him with the proper care, operation and maintenance of the equipment.

C. Record Drawings:

1. During construction, the Contractor shall keep an accurate record of deviations between the work as shown on the contract drawings and that which is actually installed. He shall secure a set of blue line prints of the plumbing and mechanical drawings for this purpose, and note changes thereon in red ink, in a neat and accurate manner, thus making a complete record of all changes and revisions in the original design which exist in the completed work. The cost of furnishing above prints and preparing these record drawings shall be included in the contract price by the Mechanical Contractor. When revisions have been shown on these prints to indicate the work as installed, the prints shall be delivered to the Architect, before final payment.

D. Valve and Damper Placement Indication:

1. Where valves and dampers are located above suspended ceilings, an indication device (as approved by the Architect) shall be located in the tile below the device.

E. PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

1. Factory Painting Systems: Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B 117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to

temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

2. Painting Systems for Metal Surfaces (Shop or Field Painting): Clean, pretreat, prime and paint metal surfaces (2 coats); except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Two finish coats are required. Apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

- a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.
- b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.
- c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

3.11 GUARANTEE OF WORK

- A. Contractor guarantees by his acceptance of the contract that work installed is free from defects in workmanship and/or materials, and that the apparatus will develop capacities and characteristics specified. If, during the period of one year or as otherwise specified from date of certificate of completion, defects in workmanship, material or performance appear, he will, without cost to the Owner, remedy such defects within a reasonable time to be specified in notice from Architect. In default thereof, the Owner may have such work done and charge cost to Contractor. Equipment guarantees from date of "start-up" or "delivery" will not be recognized.
- B. Comply, also, with the General Conditions and the Supplementary Conditions and the applicable Sections of Division 1 General Requirements.
- C. This Contractor shall service the installation for one year from date of substantial completion. This shall include emergency service and adjustment, with the exception of the oiling of motors and cleaning of filters and screens.

END OF MECHANICAL GENERAL PROVISIONS

SECTION 15020

BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and General Provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 WORK INCLUDED

- A. Piping and equipment identification.
- B. Fire and smoke stopping.
- C. Fabricated steel supports.
- D. Excavation and backfill.
- E. Painting.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this Section to the extent referenced. The publications are referenced to in the text by the basic designation only.
 - 1. American Institute of Steel Construction (AISC).
 - 2. American National Standards Institute (ANSI) Standards.
 - 3. American Society for Testing and Materials (ASTM) Publications.
 - 4. American Welding Society (AWS) Publications.
 - 5. Underwriters' Laboratories, Inc. (UL) Standards.

1.4 SUBMITTALS

- A. Comply with Section 15000, "MECHANICAL GENERAL PROVISIONS".
- B. Submit product data for the following:
 - 1. Piping and equipment identification.
 - 2. Fire and smoke stopping material.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Piping and Equipment Identification
 - 1. Seton Name Plate Corp.
 - 2. W. H. Brady Co., Signmark Division
 - 3. Communications Technology Corp.
- B. Fire and Smoke Stopping Material
 - 1. Dow Corning Corporation.
 - 2. General Electric Company.
 - 3. Nelson, A Unit of General Signal.
 - 4. Chase Technology Corp.

2.2 PIPING AND EQUIPMENT IDENTIFICATION

- A. Pipe markers shall be sub-surface printed plastic, with protective undercoating. Markers shall be permanently curled for snap-on installation and shall identify the pipe contents and direction of flow through 360 degree visibility range. Marker size and letter color and size, shall be in accord with ANSI A13.1. Background color shall be as follows:
 - 1. Fire Protection Equipment and Piping - Safety Red.
 - 2. Domestic Hot Water - Safety Yellow.
 - 3. Domestic Cold Water - Green.
 - 4. Hot Water Supply and Return - Safety Yellow.
 - 5. Chilled Water Supply and Return - Green.
 - 6. A/C Condensate Drain - Green.
 - 7. Refrigerant Liquid and Suction - Safety Yellow.
 - 8. Natural Gas - Safety Yellow.
 - 9. Marker wording shall be in accord with legend on drawings. Markers for outdoor installation shall be covered with outdoor grade acrylic plastic.
- B. Valve tags shall be 19 gauge brass, 1-1/2 inch round, with 1/4 inch high black pipe service letter abbreviation above 1/2 inch high black valve number. Pipe service letter abbreviation shall be in accord with legend on drawings. Valve tag attachment shall be 4 ply 0.018 copper wire meter seal.

- C. Valve chart frame shall be self-closing, satin-finished, extruded aluminum with glass window, 8-1/2 inch by 11 inch chart size.
- D. Equipment nameplates shall be 1/16 inch thick plastic with black satin surface and white core. Lettering shall be engraved through the surface color to expose the core color. Plate size shall be 3/4 inch by 2-1/2 inch, with 3/16 inch high lettering. Equipment identifying name and number shall be in accord with schedules on drawings. Plate manufacturer shall furnish nameplates with pre-drilled holes for permanently attaching plate to equipment with self-tapping screws or rivets.

2.3 FIRE AND SMOKE STOPPING

- A. Fire and smoke stopping material shall be a two-part silicone foam or a one-part putty, UL classified, with an HF-1 rating in accord with UL94 and a Class 1 flame spread in accord with ASTM E84. Material shall be suitable for penetration seals through fire-rated floors and walls when tested in accord with ASTM E119. Material shall not melt or soften at high temperatures, shall be suitable for direct outdoor and ultraviolet exposures, shall cure to give a tight compression fit, and shall not produce toxic fumes. Material, when heated, shall expand to fill and hold penetration closed where burn out of cable insulation, ATC tubing, etc. occurs.
- B. Where fire and smoke stopping material does not meet ASTM E84 25/50 flame spread/smoke developed rating, provide 14 gauge metal collar around pipe or duct where penetrating walls and floors in air plenums and air shafts. Provide minimum 1 inch deep neck on collar for attaching to pipe or duct. Neck for pipe collar shall be attached to collar with continuous weld. Neck and collar for duct shall be formed from angle with welded corners. Neck shall extend past sleeve minimum 1 inch all around. Provide collar for each side of wall or floor penetration. Collar may be omitted where permanent damming material meeting ASTM E84 for 25/50 flame spread/smoke developed rating is used and left in place.

2.4 PAINT

- A. Prime and finish paint is provided under DIVISION 09 - FINISHES, except as specified.
- B. All equipment shall be furnished with a factory-applied galvanized, prime paint, or finish paint finish. Touch-up damaged surfaces of equipment immediately.
- C. Paint for galvanized surfaces shall be zinc chromate.
- D. Paint wooden mounting backboards with two coats of gray enamel prior to making attachments to the board.
- E. For quality control refer to DIVISION 09 - FINISHES.

2.5 FABRICATED STEEL SUPPORTS

- A. Steel angles, channels, and plate shall be in accord with ASTM A36.
- B. Bolts, including nuts and washers, used for fabricating steel members shall be in accord with ASTM A325.
- C. Welding of steel members shall be in accord with AWS D1.1.

- D. Steel members, including fasteners, exposed to weather shall be galvanized.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation of materials and equipment shall be in accord with the manufacturer's written instructions, except as specified.

3.2 PIPING AND EQUIPMENT IDENTIFICATION

- A. Install pipe markers adjacent to each shutoff valve, at each branch connection, at equipment, on each side of wall, floor, and ceiling penetrations, where entering and leaving underground areas, and at intervals not more than 40 feet on horizontal and vertical pipe runs.
- B. In mechanical equipment rooms and equipment areas, install pipe markers adjacent to each piece of equipment, on each side of wall, floor, and ceiling penetrations, and at intervals not more than 20 feet on all pipe runs.
- C. Medical gas piping (oxygen, vacuum, medical air) shall have pipe markers at intervals not more than 20 feet and at least once in each room and every story traversed by the piping system. Pipe shall be cleaned prior to marker installation.
- D. Attach valve tag to stem of each valve. Valve numbers shall follow in sequence the Owner's existing valve numbers, where applicable.
- E. Provide pressure-sensitive vinyl marker for each valve located above lift-out tile ceilings. Apply marker to underside of ceiling grid support system adjacent to valve location. Color of marker shall match color of piping identification system.
- F. Provide triplicate valve charts. Chart information shall indicate job name, Contractor name, date of installation, valve number, valve location, valve purpose, and system in which installed. Mount framed chart in equipment room, and insert copy of chart in each operating and maintenance manual.
- G. Permanently affix nameplate to each item of equipment with self-tapping screws or rivets. Where irregular surface impede direct attachment of plates, affix plate to sheetmetal bracket and attach bracket to equipment with screws or bolts.

3.3 FIRE AND SMOKE STOPPING

- A. Fire and smoke stopping is required in the following locations:
 - 1. Where exposed and concealed horizontal pipes, tubes, and wires penetrate fire rated walls, shaft walls, and smoke barriers.
 - 2. Where exposed and concealed vertical pipes, tubes, and wires penetrate rated and non-rated floors.
 - 3. Where exposed and concealed horizontal ducts penetrate fire rated walls, shaft walls, and smoke barriers, except where fire or smoke dampers are installed in ducts.

- 4. Where exposed and concealed vertical ducts penetrate rated and non-rated floors, except where fire or smoke dampers are installed in ducts.
- B. Fill annular space between pipe and sleeve, or between duct and sleeve, with approved material. Depth of material shall be in accord with laboratory tests for 1, 2, or 3 hour rated assemblies.
- C. Damming material may be temporary non-fire approved, or permanent fire-approved. Where permanent fire-approved damming material is used depth of fire and smoke stopping material may be decreased in accord with manufacturer's recommendations. Temporary damming material shall be removed after installation of fire and smoke stopping material.
- D. Seal all gaps or voids in cured foam with material to match the fire and smoke stopping material.
- E. Trim excess cured foam from around all openings and leave smooth, flush surface.
- F. Position metal collar on pipe or duct penetrating floors or walls in air plenums and air shafts. Secure neck of collar to duct with screws, and to pipe with metal draw band.

3.4 PAINTING

- A. Remove all dirt, rust, scale, grease, pipe dope, solder flux, and welding slag from all surfaces to be painted.
- B. Paint immediately, under this DIVISION, all damaged galvanized surfaces, including welds. Paint galvanized metal surfaces behind grilles with two coats of flat black paint.
- C. Apply rust inhibitive primer to ferrous surfaces of shop fabricated steel supports.

3.5 FABRICATED STEEL SUPPORTS

- A. Fabricated steel supports may be shop or field-fabricated, and shall be in accord with details on drawings or as required.
- B. Steel members shall be saw cut, with corners ground smooth, and shall be assembled with welded or bolted connections at Contractor's option. Connections shall be in accord with specified AISC Publications.

3.6 PLACING OF EQUIPMENT

- A. Coordinate setting of equipment with the requirements of other trades so as to avoid conflicts and to insure compatibility. Equipment shall not block access for installation of other equipment.
- B. Set base mounted equipment on permanent and finished supports. Temporary support, if any, shall be removed prior to making final pipe, duct, or electrical connections to equipment.

END OF BASIC MATERIALS AND METHODS

SECTION 15030

ADJUSTING, BALANCING AND SYSTEM TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 WORK INCLUDED

- A. Prebalance of existing air handling units prior to start of any demolition.
- B. Checking installation for conformity to design.
- C. Checking each piece of equipment for proper installation and operation.
- D. Balance of air and water distribution systems including adjustment and measurement. Domestic hot water recirculation systems shall be balanced under this section.
- E. Electrical measurement.
- F. Verification of performance of all equipment and automatic controls.
- G. Checking sound levels and vibration isolators for proper function and measurement and correction where a problem or question of acceptability exists.
- H. Recording and reporting results.

1.3 REFERENCES

- A. Air Diffusion Council (ADC) 1062R3 Equipment Test Code.
- B. Associated Air Balance Council (AABC) National Standards for Field Measurements and Instrumentation, Total Balance System Balance, Air Distribution - Hydronic Systems, Volume 1.
- C. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

1.4 SUBMITTALS

- A. Submit in accordance with General Conditions, Division 1 Sections and Section 15000, "MECHANICAL GENERAL PROVISIONS".
- B. Submit test and balance personnel qualifications.
- C. Submit complete description of procedures to be used prior to beginning of any balancing.
- D. Submit design review report within 45 days after contract award.

- E. Submit Test and Balance Report including schedules of test data readings.

1.5 QUALITY ASSURANCE

- A. Adjusting, balancing and testing procedures and compilation of test data shall be performed by a Certified Test and Balance Engineer or by personnel trained and supervised by a Certified Test and Balance Engineer.
- B. Test and balance personnel shall be qualified to perform testing and balancing in accordance with AABC or NEBB procedures.

1.6 SPECIAL REQUIREMENTS

- A. Testing and balancing contractor shall be an independent contractor under the general contractor. Testing and balancing contractor shall not be associated with the mechanical contractor and shall not report to the mechanical contractor.

1.7 DESIGN REVIEW REPORT

- A. Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the accomplishment of the testing, adjusting, and balancing work requirements of this section or result in unacceptable noise or vibration levels. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.8 TOLERANCES

- A. Balance final fluid flows to within plus 10 percent or minus 5 percent of specified quantities. Establish diversity with Engineer prior to proceeding with balancing.

1.9 PREBALANCE

- A. Perform prebalance (airflow, total static pressure, and motor amperage(s)) on the units listed hereafter prior to any demolition work. Submit prebalance data to Architect.

1. Existing RTUs, Glenns & Warsaw Campus.

1.10 GENERAL COMMENTS

- A. Water Balance: Readings from venturi flow meters, or automatic pressure independent flow control devices shall be given highest priority as to accuracy. Where neither is specified pump curves and chiller pressure drops are to be correlated to establish flow. Pressure drop across coils or chillers is to be used to proportion flow. Volt and ampere readings will be used as checks. Temperature data will be used only as a performance check and not for balancing.
- B. Air Balance: Readings from a pitot tube traverse will be given highest priority as to accuracy. Terminal flow as established by velometer or manufacturers cfm/pressure curves will be used to pro-rate air flow. Pressure readings as well as voltage and ampere readings will be used for check purposes only. Temperature readings will be used as a check against performance.

- C. Prior to start of balancing, this Contractor shall review balancing test procedures with the Architect. Contractor shall provide information and assistance as required in cooperation with the test, adjust and balance service.

1.11 ACCEPTABLE TAB CONTRACTORS

- A. Virginia Air Balance & Control Corporation (Norfolk, VA)
- B. Testing Specialties Inc. (Chesapeake, VA)
- C. HVAC Testing Ltd. (Chesapeake, VA)

PART 2 - PRODUCTS

Not applicable

PART 3 - EXECUTION

3.0 TEST AND BALANCE REPORT VERIFICATION

- A. Schedule with Architect, Engineer, and Owner. At the time of final inspection, the Test And Balance (TAB) agency may be required to recheck, in the presence of Engineer representative specific and random selections of data, and water and air quantities recorded in the certified report. Points and areas for recheck shall be selected by the representatives. Selections for recheck will not exceed 20% of the total number tabulated on the report. If random test proves a measured flow deviation of 10% or more from that recorded in the certified report listings, the report will be rejected. At this time all systems shall be readjusted and tested, new data recorded, new certified report submitted, and new inspection tests made, all at no additional cost to the Owner. The TAB agency shall provide the representative with a technician for a maximum of 24 hours in order to verify report data and solve problems.

3.1 INTENT OF DRAWINGS AND SPECIFICATIONS

- A. Review drawings and specifications with regard to adjusting and balancing.
- B. Additional balancing devices which, in the opinion of the Contractor, are required for the adjusting and balancing of the systems should be brought to the Architect's attention in the Design Review Report.
- C. Failure of the Contractor to address such additional means shall not obviate the responsibility of the Contractor to properly adjust and balance the systems.

3.2 WATER BALANCE

- A. Ascertain that piping systems have been cleaned, flushed, drained and properly refilled and that all strainer baskets have been removed, cleaned and properly reinstalled prior to beginning water balancing procedure.
- B. Constant flow pumping system using manual balancing valves and/or butterfly valves with memory stop has been specified for the chilled water and hot water systems.
 - 1. With all balancing devices and valves wide open to coil, read and record pressure drop across each coil.

2. With all balancing devices and valves wide open to coil, read and record pressure drop across each pump. Also read and record pressure drop across pump at shut off. Plot point on submitted pump curve.
 3. If pressure drop across all of the coils exceeds the design and the pump pressure readings indicated a flow in excess of design, the pump impeller may be trimmed. Submit this data to Engineer for early review, before proceeding with balancing to determine if an impeller trim is warranted.
- C. Variable flow pumping systems using manual balancing valves with memory stop have been specified for the chilled and hot water systems.
1. Simulate system diversity by isolating random terminal equipment to approximately match the difference between total connected GPM and pump flow rate. Do not isolate groups at the end, middle, or start of the piping system. Randomly isolate units throughout the system. With balancing devices and valves wide open to the remainder of the terminal units, read and record pressure drop across open coils and across each pump. Also read and record pressure drop across each pump at shut off. Plot point on submitted pump curve.
 2. Redo step one for the terminal units initially isolated with balancing devices and valves wide open while isolating previously balanced terminal coils to simulate system diversity as directed above.
 3. If pressure drop across all of the coils exceeds the design and the pump pressure readings indicated a flow in excess of design, the pump impeller may be trimmed. Submit this data to Engineer for early review, before proceeding with balancing to determine if an impeller trim is warranted.
 4. Do not simulate diversity by balancing all coils to the diversity percentage.

3.3 AIR BALANCE

- A. Check system visually and audibly for leakage and verify filters have been replaced. Proceed with balancing as outlined by AABC or NEBB.
- B. Adjust all air handling apparatus to deliver the specified quantity of air at the specified temperatures to all areas of the building served by air systems.
- C. Determine air volume in ducts by use of pitot tube, and inclined manometer.
- D. Determine air quantity through air devices by use of velometer or flow hood with direct readout meter calibrated in CFM. When using velometer, velometer nozzle shall be as recommended by air device manufacturer. Calculate air quantity based on air device area factors provided by the air device manufacturer. Where manufacturers publish cfm vs. air pressure ratings these may be used as indicators of flow.

3.4 CONTROLS ADJUSTMENT

- A. Check the automatic temperature controls to ascertain that the specified sequence of operation is occurring. Record thermostat or temperature sensor set point and room conditions in each space.

- B. Coordinate onsite meetings during TAB work with the Controls Subcontractor for set point adjustment thru DDC controls.

3.5 TEST DATA SCHEDULES

- A. Submit typewritten schedules of test data readings.
- B. Schedules shall record the specified reading, the first reading taken and the final balanced reading for the following items:
 - 1. Motors:
 - a. Designation.
 - b. Nameplate HP, voltage and full load amperes.
 - c. RPM.
 - d. Motor amperes and voltage under operating conditions.
 - e. For belt drive applications, motor amperes and voltage under no load condition.
 - 2. Fans:
 - a. Designation.
 - b. Nameplate data.
 - c. RPM.
 - d. Static pressure, inlet and discharge.
 - e. CFM from pitot tube traverse of discharge duct.
 - f. Final pitot tube traverse sheets showing all readings.
 - 3. Main and Submain Ducts:
 - a. Designation and location.
 - b. CFM from pitot tube traverse.
 - c. Final pitot tube traverse sheets showing all readings.
 - 4. Terminal Units:
 - a. Designation.
 - b. Nameplate data.
 - c. CFM, maximum setting on regulator.
 - d. CFM, minimum setting on regulator.
 - e. Final pitot tube traverse sheets showing all readings.
 - 5. Air Outlets and Inlets:
 - a. Room designation.
 - b. Type of outlet.
 - c. Design CFM.
 - d. Measured CFM.
 - e. Method of measurement.
 - f. All final measurement readings.
 - 6. Pumps:
 - a. Designation.

- b. Nameplate data.
- c. RPM.
- d. Pressure suction and discharge.
- e. Pressure entering and leaving strainer.

7. Coils - Water:

- a. Designation.
- b. Nameplate data (if available).
- c. Pressure entering strainer valve and leaving flow control service.
- d. Pressure entering and leaving flow control device where two taps are provided.
- e. Temperature entering and leaving water.
- f. Static pressure, entering and leaving air.
- g. Dry bulb and wet bulb temperature, entering and leaving air (4 readings at quarter points where coils are over 20 sq. ft. F.A.)
- h. CFM over coil including all final readings used to obtain cfm.
- i. GPM from flow regulator nameplate.

3.6 OPERATING TESTS

- A. Verification of HVAC control system. The TAB agency shall coordinate with and be assisted by building controls contractor in verifying the operation and calibration of all HVAC and temp control systems. Verify all components are installed in accordance with project requirements and are functional including all electrical interlocks, damper sequences, air and water resets, fire and freezestats and other safety devices.
- B. Operate systems to demonstrate that systems have been properly adjusted and balanced, and to demonstrate that the systems' performance conforms with the intent of the specifications and drawings.
- C. Conduct tests on each system with natural building heating and/or cooling loads for a minimum 4 hours duration.
- D. Conduct tests for one season only. During season not tested, make adjustments as necessary to demonstrate that the systems' performance in season not tested conforms with the intent of the specifications and drawings.

3.7 EQUIPMENT MARKING

- A. Mark equipment settings, including damper control positions, ductwork balancing dampers, valve indicators, fan speed controls and similar controls and devices, to show final settings at completion of T&B work. Provide markings with paint or other suitable permanent identification materials.

END OF ADJUSTING, BALANCING AND SYSTEM TESTING

SECTION 15055

DEMOLITION

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and General Provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 SCOPE

- A. This Contractor shall be responsible for removal of and modifications to the existing piping, ductwork and equipment as hereinafter noted and as shown on the Drawings. All material removed and not reused in remodeling shall become the property of this Contractor and promptly removed from the site unless the Owner specifically asks to retain certain equipment.
- B. This Contractor shall remove existing piping, ductwork, equipment, and appurtenances, etc., as shown on the Drawings and as specified.
- C. Coordinate demolition with hazardous material removal / abatement contractor, drawing notes and contract specifications.

PART 2 - PRODUCTS

Not applicable

PART 3 - EXECUTION

Not applicable

END OF DEMOLITION

SECTION 15060
HVAC PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification sections, apply to work of this section.

1.2 WORK INCLUDED

- A. Chilled water, hot water, and chemical feed system piping.
- B. Condensate drain piping.
- C. Pipe welding.
- D. Inspection of pipe welds.
- E. Examination of pipe welds.
- F. Leak testing of piping systems.

1.3 QUALITY ASSURANCE

- A. Furnish certified record of welding qualification test for each welder, and welding operator, prior to beginning welding operations.
- B. Furnish certified laboratory test report for each weld specimen subjected to laboratory testing.

1.4 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this Section to the extent referenced. The publications are referenced to in the text by the basic designation only.
 - 1. American Iron and Steel Institute (AISI) Publication:
 - a. Steel Products Manual.
 - 2. American National Standards Institute (ANSI) Standards.
 - 3. American Society of Mechanical Engineers (ASME) Publications:
 - a. Section VIII Pressure Vessels, Division 1.
 - b. Section IX Welding and Brazing Qualifications
 - 4. American Society for Testing and Materials (ASTM) Publications.
 - 5. American Welding Society (AWS).

6. The Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS).

1.5 WELDING

- A. Piping welded in accord with qualified procedures using performance qualified welders and welding operators. Full penetration welds are required.
- B. The Contractor is responsible for testing and qualifying the welders assigned to do the work, including the required test welds.
- C. Submit certified record of welding qualification test for each welder assigned to do the work.
- D. Each weld in the piping system, including required test welds, will be visually examined by the Architect for imperfections in accord with ANSI B31.1.
- E. Defective work shall be corrected in accord with the General Conditions.
- F. Welds exhibiting visual evidence of poor workmanship or excessive leaking under test, at the Architect's option, shall be subjected to additional nondestructive inspection or mechanical testing in accord with ANSI B1.0 or B4.0.
 1. Additional tests will require the services of a certified testing laboratory.
 2. Should additional tests detect unacceptable defects not detectable by visual inspection the work shall be deemed to be concealed and the cost of the additional tests shall be borne by the Contractor in accord with the General Conditions.

1.6 SUBMITTALS

- A. Comply with Section 15000, Mechanical General Provisions.
- B. Submit manufacturer's data and certificate of conformance on the following:
 1. Pipe
 2. Pipe fittings
- C. Submit certified record of welding qualification test for each welder.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment shall conform to the respective publications and other requirements specified herein.

2.2 PIPE

- A. Where more than one type of material is listed for a specific system the Contractor may select any of the types of materials specified for that particular piping system.

B. Materials for Piping Systems:

<u>Systems</u>	<u>Materials</u>
1. Chilled Water, Chemical Feed, Hot Water, 2-1/2" and above	a. Pipe, Steel: ASTM A53, ASTM A120, standard weight, black. Pipe Fittings, Steel: ASTM A234, marking WPA for welding fittings. Butt-welding Fitting: ANSI B16.9. Socket Welding Fittings: ANSI B16.11. Malleable iron threaded fittings, Class 150 & 300; ANSI B16.3.
2. Chilled Water, Chemical Feed, Hot Water, 2" and below	b. Pipe, Copper Tubing: ASTM B88, hard drawn, type L. Pipe Fittings: ANSI B16.22, wrought copper. Solder Metal: ASTM B32, 95-5 (tin-antimony-grade 95 TA).
3. Condensate Drains	a. Pipe, Copper Tubing: ASTM B88, hard drawn, type L. Pipe fittings: ANSI B16.22, wrought copper. Solder Metal: ASTM B32, 95-5 (Tin-antimony grade 95 TA). (size 1 in. maximum.) b. Pipe, Copper Tubing: ASTM B306 Copper drainage tube, (DWV). Pipe Fittings: ANSI B16.23, cast copper alloy solder joint drainage fittings, DWV. Solder Metal: ASTM B32, 95-5 (tin-antimony-grade 95TA). (size 1-1/4 in. and larger). c. Pipe, PVC: ASTM D1785, Schedule 40. Pipe Fittings: ASTM D2466, PVC. Solvent Cement: ASTM D2564.

2.3 PIPE THREADS

- A. Pipe threads shall conform to ANSI B2.1. Threads that are corroded, stripped, chipped, flattened, or damaged in any other way, are not acceptable.

2.4 UNIONS

- A. Unions shall be used on pipe sizes 2-1/2 inches and smaller.
 - 1. Unions for steel pipe shall be in accord with ANSI B16.39, malleable iron, threaded, Class 150 and 300, black or galvanized to match adjacent piping.
 - 2. Unions for copper pipe shall be combination wrought copper/red bronze, or cast bronze, solder ends, Class 150.
- B. Unions for pipe sizes 3 inches and larger shall be companion flange type.
 - 1. Companion flanges for steel pipe shall be steel, slip-on welding type, 150 lb.
 - 2. Companion flanges for copper pipe shall be in accord with ANSI B16.24, cast-bronze, solder connections, 125 lb.
- C. Dielectric unions shall have metal connections on each end threaded to match adjacent piping. Metal components shall be separated by nylon insulator to prevent current flow between dissimilar metals. Unions shall be suitable for the required system operating temperatures and pressures.

2.5 FLANGES

- A. Bronze flanges shall be in accordance with ANSI B16.24.
- B. Steel flanges shall be in accordance with ASTM A181, Class 60, with dimensions in accord with ANSI B16.5.
- C. Flanges shall have the manufacturer's trademark affixed in accord with MSS SP-25 so as to permanently identify the manufacturer.

2.6 GASKETS

- A. Flange gaskets shall be fiber, plastic, rubber, or other synthetic material suitable for the intended service.
- B. Nonmetallic gaskets shall be in accord with ANSI B16.21.
- C. Rubber-compound gaskets shall be in accord with ASTM D2000, No AA 708A132. Rubber in gasket shall have nonblooming surface, durometer hardness of 75 plus or minus 5, minimum tensile strength of 1500 psi, and a minimum elongation of 150 percent.

2.7 BOLTS AND NUTS

- A. Squarehead bolts and heavy hexagon nuts shall be in accord with ANSI B18.2.1 and B18.2.2, ASTM A307, A575, or A576.
- B. Bolts for underground service shall be in accord with ASTM A325.

2.8 MECHANICAL JOINTS

- A. Mechanical joints may be provided in lieu of unions and welded, flanged or screwed piping joints in above ground black steel piping for chilled water systems.
- B. Pipe with wall thicknesses less than Schedule 30 in sizes 8 inches and larger, or Schedule 40 in sizes smaller than 8 inches shall not be joined with couplings used with pipe having cut grooves. Use rolled grooves only.
- C. Mechanical joints shall be of the external coupling type for use with cut grooved or rolled grooved end pipes, fittings, and valves.
- D. Mechanical couplings shall be self-centering, and shall engage and lock in place the grooved end pipes, fittings, and valves.
- E. Coupling housing clamps shall be malleable iron casting fabricated in two or more parts.
- F. Coupling gaskets shall be molded synthetic rubber.
- G. Coupling assembly shall be held together by two or more track-head, square, or oval neck steel bolts.
- H. The coupling assembly shall be designed for not less than 125 psi service at 230 degrees F, and shall be appropriate for the system pumping head plus the system static head.
- I. Mechanical couplings and fittings shall be of the same manufacturer.

2.9 PIPE FITTINGS

- A. Pipe fittings, where applicable, shall have the manufacturer's trademark affixed in accord with MSS SP-25 so as to permanently identify the manufacturer.

2.10 CUTTING OIL

- A. Thread-cutting oil shall be an all-purpose lubricant free from animal or vegetable compounds.

2.11 PIPE THREAD COMPOUND

- A. Screwed pipe joints shall have male threads only coated with graphite, or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene (PTFE) tape applied.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Pipe tubing shall be cut square and smooth, shall have burrs removed by reaming, and shall have scale, dirt, and welding slag removed from inside and outside.
- B. Pipe fittings shall be examined for damage and defects, and shall have scale, dirt, and rust removed from inside and outside. Damaged or defective fittings, and fittings showing excessive rust, shall be replaced with acceptable fittings.

- C. Use wire brush and compressed air to remove rust, dirt, and other foreign material from pipe and fitting threads prior to application of pipe thread compound, or PTFE tape.
- D. Use flat file to remove welding spatter and slag from face of flanges. Chipping or grinding is not permitted.

3.2 INSTALLATION

A. General Requirements

1. Installation shall be as required by the applicable Code listed in the General Conditions, Supplementary Conditions, and the applicable Section of Division 1 General Requirements. Comply with Section 15000, Mechanical General Provisions.
2. Pipe openings shall be closed with caps or plugs during installation.
3. Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Above ground piping shall run parallel with the building lines, unless otherwise indicated. Pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 1 inch clearance between finished covering on the different services. Bare and insulated pipes shall not bear directly against building structural elements so as to transmit sound to the structure or prevent flexible movement of the lines.
4. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted. Change in direction shall be made with fittings, except that bending of steel and copper pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.
5. Allowance shall be made throughout for expansion and contraction of piping subject to expansion. Each riser and horizontal run of piping shall be provided with expansion joints, or expansion compensators where required. Piping shall be securely anchored as required or where indicated to force expansion to the expansion device without bending, binding, or misalignment of pipe. Branch connections from mains to risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Where indicated, in lieu of expansion joints, or expansion compensators, horizontal runs of pipe shall be anchored at approximately midway of the run to force expansion, evenly divided, toward the mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining.
6. Joints between sections of black steel pipe and between black steel pipe and fittings size 2-1/2 inches and larger shall be welded.
7. Mechanical joints may be provided in lieu of welded or flanged piping connections in black steel piping. Pipe grooving and coupling installation shall be in accord with the manufacturer's written instructions.
8. Welded joints shall be fusion welded unless otherwise required. Changes in direction of piping shall be made with welding fittings only, except that bending of

pipe sizes 4 inches and smaller will be permitted. Mitering or notching of pipe to form elbows and tees, or other similar type construction, will not be permitted. Branch connections may be made with either welding tees or branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of welds shall conform to Article 1.5 WELDING this Section. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded at no change in Contract price. Electrodes shall be stored and dried in accord with AWS D1.1, or as recommended by the manufacturer. Electrodes that have been wetted, or that have lost any of their coating, shall not be used. The welding process shall be performed in accord with NFPA No. 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.

9. Threaded joints shall be made with tapered threads in accord with ANSI B2.1, and made tight with an approved pipe thread joint compound or material, applied to the male threads only. Use compounds sparingly and apply with caution to ensure that compounds do not enter piping systems. When pipe joint is made up a maximum of 3 threads shall be visible.
10. Joints in copper tubing shall be made with solder-type fittings. Outside surface of the tube where engaged in the fitting, and inside surface of the fitting in contact with the tube, shall be cleaned with an abrasive material before soldering. Self-cleaning compounds are not allowed. Care shall be taken to prevent annealing of tube and fittings when making connections. Solder joint shall be made with flux and wire form solder, except brazed joints. The flux shall be mildly corrosive liquid or petroleum based paste containing chlorides of zinc and ammonium. Solder shall be applied and drawn through the full fitting length. Excess solder shall be wiped from joint before solder hardens. Joints in copper tube sizes 2-1/2 inches and larger shall be made with heat applied uniformly around the entire circumference of the tube and fittings by a multiflame torch. Use of oxy-acetylene cutting torch in lieu of multiflame torch is not permitted.
11. Exterior surfaces of steel pipe, and pipe fittings, installed below ground shall be thoroughly cleaned of foreign matter by wire brushing and solvent cleaning. The pipe shall be primed and immediately wrapped with tape, applied with a 50 percent overlap. Tape shall conform to AWWA C203, and primer shall be as recommended by the tape manufacturer. Joints and fittings shall be covered with the same primer and tape. Fittings shall be coated and wrapped after piping has been tested. Pipe shall be coated and wrapped during installation.
12. Silver brazing joints shall be in accord with MSS SP-73 Silver Brazing Joints for Wrought and Cast Solder Joint Fittings.
13. Clean PVC fitting hubs and pipe ends with PVC primer prior to application of solvent cement. Solvent cement shall be applied to male ends only. Seal shall be uniform around entire perimeter of joint or joint shall be removed and remade.
14. Connections between ferrous and nonferrous metallic pipe shall be made with dielectric unions or flanges.
15. Provide unions or flanged connections at all equipment.

16. Unions and flanges shall not be concealed in walls, partitions, or above inaccessible ceilings.

B. Hydronic HVAC Systems Additional Requirements

1. Make branch connections to top of mains for upfeed arrangement, and to bottom of mains for downfeed arrangement, except where main and branch line are of equal size the branch connections may be made to the side of the main for both upfeed and downfeed applications.
2. Slope horizontal condensate drain piping minimum 1/4 inch per foot.
3. Provide water seal in the condensate drain from each A.C. unit. The depth of each seal shall be equal to the total static pressure rating of the unit to which the seal is connected. Water seals shall be constructed of two tees and an appropriate U bend with the open end of each tee plugged.

3.3 LEAK TESTING

- A. The Architect will witness all leak tests. Notify Architect at least 24 hours in advance of tests.
- B. Where tests are to be witnessed and approved by the Building Official, notify Official and obtain approval. Where written approval is furnished, submit copy of approval.
- C. Work, or portions of work, that is altered in any way after testing and approval shall be retested, witnessed, and approval obtained.
- D. Work requiring testing shall not be covered, or otherwise concealed, until testing is completed and approval is granted.
- E. Systems requiring hydrostatic tests shall be protected from damage caused by freezing. After tests are completed, drain all sections of pipe, including traps, or fill undrained sections and traps with antifreeze solution. Vent all high points to release vacuum and ensure complete drainage of closed systems, and blow out piping with compressed air to remove trapped water.
- F. Duration of tests, unless specified otherwise, shall be the time required to examine each joint in the system being tested.
- G. Systems requiring hydrostatic testing under pressure shall be vented at high points to ensure that all piping is completely filled with the testing medium.
- H. During tests, isolate system components that have test pressures less than pressures specified for system tests.
- I. Use clean soapy water applied to exterior of joints to locate leaks in systems using compressed air, dry carbon dioxide, or nitrogen, under positive pressure as a test medium.
- J. The various piping systems shall be leak tested as specified below:
 1. Chilled Water, Hot Water, and Chemical Feed shall be tested with water at 1-1/2 times the system working pressure, but not less than 100 psig. Joints will be

visually examined for leaks. Welded joints shall be hammer tested under pressure.

- K. Leaks, if any, shall be located, repaired, and retested in accord with the test method specified for the system in which the leaks are located.

END OF HVAC PIPE AND PIPE FITTINGS

SECTION 15090

SUPPORTS, HANGERS, ANCHORS, AND SLEEVES

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 WORK INCLUDED

- A. Inserts and upper attachments.
- B. Pipe hangers and supports.
- C. Pipe anchors.
- D. Duct hangers and supports.
- E. Pipe and duct sleeves.
- F. Fabricated steel supports.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this Section to the extent referenced. The publications are referenced to in the text by the basic designation only.
 - 1. American Institute of Steel Construction (AISC).
 - 2. American National Standards Institute (ANSI).
 - 3. American Society for Testing and Materials (ASTM).
 - 4. American Welding Society (AWS).
 - 5. The Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS).
 - 6. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA).

1.4 SUBMITTALS

- A. Comply with Section [22 05 00], Plumbing General Provisions.
- B. Submit product data for the following:
 - 1. Inserts and upper attachments
 - 2. Pipe hangers and supports

3. Anchors
4. Saddles and shields

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Fee and Mason Manufacturing Co.
- B. Grinnell.
- C. National Pipe Hanger Co.
- D. B-Line.

2.2 MATERIALS

- A. Design of pipe supporting elements shall be in accordance with ANSI B31.1.
- B. Steel hangers shall be fabricated in accordance with the requirements of MSS SP-58.
- C. The selection and application of pipe hangers and supports shall be in accordance with MSS SP-69.
- D. Steel angles, channels, and plate shall be in accordance with ASTM A36.
- E. Bolts, including nuts and washers, used for fabricating steel members shall be in accordance with ASTM A325.
- F. Welding of steel members shall be in accordance with AWS D1.1.
- G. Duct hangers and supports shall be in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, as applicable.
- H. Hangers and supports, including attachments, exposed to weather shall be hot dipped galvanized.

2.3 PIPE SUPPORT ELEMENTS

- A. The type numbers listed for pipe supporting elements are in accordance with MSS SP-58, except where a figure number is preceded by a manufacturer's name the manufacturer's figure number is listed.

1. Inserts

- a. For minimum 3 inch thick concrete use type 18 for poured in place and precast concrete.
- b. For poured in place and precast concrete less than 3 inch thick, and of sufficient strength to support attached load, use 4 inch square by 3/8 inch thick steel plate drilled for rod and recessed into top of slab. Attach rod to bottom of plate with fillet weld and to top of plate with bevel weld. Provide

spacers to position plate at proper height. Extend rod through form and attach nut to secure plate in permanent position.

- c. Where concrete slab will not support attached load span space between ribs with steel angle or channel attached to ribs with inserts.
2. Upper Attachments: Type 21, 22, 28, 29, or 30 beam clamps. Use Type 17 weldless eye nut for rod attachment to Type 21 and 22 upper attachments. Angle iron or channel clamps shall be Type 20 with a malleable iron heel plate added.
3. Hangers
- a. Type 1 for all bare and insulated piping, unless indicated otherwise.
 - b. Type 41 or 43 where hanger rod deviates more than 4 degrees from the vertical, where pipe expansion exceed 1/2 inch, and where Type 39 insulated protection saddles are used on hot piping.
 - c. Hangers in contact with copper pipe shall be copper plated.
 - d. Parallel piping may be supported by trapeze hangers consisting of steel angle, channel, or beam suspended by steel rods attached to upper structure. Piping may be supported above, or suspended below, the angle channel, or beam.
4. Supports
- a. Type 38 adjustable saddle for pipe supported from below where horizontal movement is negligible.
 - b. Type 31 welded steel bracket, as applicable, for piping run adjacent to, and parallel with, walls where support from above or below is not feasible.
 - c. Type 8 or 42 riser clamp for vertical risers. Provide Type 48 spring cushion where pipe expansion exceeds 1/2 inch and for plastic piping.
 - d. Fabricated steel supports for pipe anchors and guides shall be as detailed on the drawings. Where supports as detailed do not suite job conditions notify Architect prior to proceeding with fabrication.
 - e. Where supports are in contact with copper pipe, provide copper plated support, or wrap pipe with sheet lead.
5. Anchors
- a. Fee and Mason Figure 140 for black steel pipe.
 - b. Fee and Mason Figure 141 for nonferrous pipe.
 - c. Where anchors are in contact with copper pipe provide copper plated anchor, or wrap pipe with sheet lead.

6. Saddles and Shields

- a. Type 39 insulation protection saddle for black steel hot piping.
- b. Type 40 insulation protection shield for piping size 2 inch and smaller, except black steel hot piping.
- c. Fee and Mason Figure 71 rigid insulation saddle for pipe size 2-1/2 inch and larger, except black steel hot piping.
- d. Rigid insulation saddle shall be a single bonded unit consisting of a galvanized metal shield, aluminum faced waterproof jacket, and a molded section of rigid polyurethane foam insulation. Rigid urethane foam shall have a density of 4 pounds per cubic foot, a thermal conductivity of 0.13 Btu-in/sq.ft./hr./deg. F at 75 deg. F mean temperature, and shall be suitable for 275 degree F continuous operating temperature.

2.4 SLEEVES

- A. Sleeves for pipes penetrating concrete and masonry walls, stud framed fire rated walls, and where extending above floor in wet areas, shall be schedule 40 steel pipe.
- B. Sleeves for pipe penetrating poured-in-place concrete floors and roofs may be steel pipe, or galvanized sheet metal of sufficient gauge to prevent collapse or distortion during construction.
- C. Sleeves for pipes penetrating exterior walls above and below grade, shall consist of a steel pipe sleeve with anchor and water stop plate, and a multiple link sealing element consisting of rubber sealing links, pressure plates, and connecting bolts and nuts. Sleeve assembly shall be suitable for 250 deg. F service.
- D. Sleeves for ducts penetrating concrete and masonry walls, stud framed fire rated walls, and poured-in-place concrete floors and roofs shall be 18 gauge sheet metal.

PART 3 - EXECUTION

3.1 PIPE SUPPORT ELEMENTS

- A. Inserts shall be placed and secured to concrete forms in correct locations.
- B. The maximum spacing between pipe supports for straight runs shall be in accordance with MSS SP-69. Pipe hangers or supports shall be spaced not over 5 feet apart at heavy fittings and valves. A hanger shall be installed at a distance not to exceed 1 foot from each change in direction of piping, including branch connections to mains.
- C. Supports for vertical piping shall be located at each floor or at intervals of not more than 15 feet and at intervals of not more than 8 feet from end of risers. Where supports are provided on intermediate floors spaced 15 feet or less between floors, no additional supports are required other than those specified for end of risers.
- D. Pipe supports for insulated pipe shall have a diameter of sufficient size to include the insulation. Hanger rod size shall be the manufacturer's standard size for the hanger to which it attaches.

- E. Hanger rods shall be subject to tensile loading only. Where lateral or axial movement is anticipated, use suitable linkage in hanger rod to permit swing.
- F. Provide hex head nut on rod at top and bottom of clevis hanger yoke, and at each rod connection to intermediate and upper attachment. Rod nuts shall be securely locked in place.
- G. The location of hangers and supports shall be coordinated with the structural work to ensure that the structural members will support the intended load.
- H. Hangers shall be fabricated to permit adequate adjustment after erection while still supporting the load. Turnbuckles shall be provided where required for vertical adjustment of the piping.
- I. Fabrication and installation of pipe hangers and supports shall be in accordance with MSS SP-89.

3.2 FABRICATED STEEL SUPPORTS

- A. Steel supports for ducts, pipe anchors, and piping supported from below shall be fabricated in accordance with AISC Specification for the Design, Fabrication and Erection of Structural Steel for buildings.
- B. Steel for supports shall be saw cut, with sharp edges ground smooth. After fabrication remove all foreign material, including welding slag and spatter, and leave ready for painting or galvanizing, as applicable.

3.3 SLEEVES

- A. Secure sleeves to forms for concrete construction. Ensure sleeves are not disengaged or misaligned by concrete placement operations.
- B. Provide temporary cap for open end of sleeves to prevent entrance of concrete.
- C. Provide temporary internal bracing where required to prevent distortion of sheet metal sleeves by concrete placement operations.
- D. Sleeves shall not be installed in structural members, except where indicated or approved.
- E. Furnish sleeves to masonry contractor in advance of masonry work. Furnish dimensioned drawings indicating exact location of sleeves.
- F. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface, except as indicated otherwise.
- G. Sleeves passing through floors in wet areas, such as areas containing plumbing fixtures or floor drains, shall extend a minimum of 4 inches above the finished floor. Duct sleeves in wet areas shall be enclosed with 4 inch concrete curb.
- H. Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 1/4 inch clearance all around between the pipe or duct and inside of sleeve, or between jacket over insulation and sleeve.

- I. Provide membrane clamping device on sleeves for waterproof floors.

END OF SUPPORTS, HANGERS, ANCHORS, AND SLEEVES

SECTION 15100

HVAC VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification sections, apply to work of this section.

1.2 WORK INCLUDED

- A. In-line strainer valves.
- B. Gate valves.
- C. Drain valves.
- D. Balancing valves.

1.3 SUBMITTALS

- A. Comply with Section 15000, Mechanical General Provisions.
- B. Submit product data for each valve listed in paragraph 1.2, WORK INCLUDED.
- C. Manufacturer's Data
 - 1. Valves
- D. Certificates of Compliance:
 - 1. Valves

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Gate and Drain Valves
 - 1. Stockham
 - 2. Lunkenheimer
 - 3. Crane
 - 4. Nibco
 - 5. Milwaukee Valve Co., Inc.
 - 6. Hammond Co.

B. Balancing Valves

1. Bell & Gossett
2. Armstrong
3. Taco

2.2 VALVE CONNECTIONS

- A. Provide valves suitable to connect to adjoining piping as specified for pipe joints. Use pipe size valves.
- B. Thread or sweat pipe sizes 2 inches and smaller. Thread pipe sizes 2-1/2 and 3 inches.
- C. Flange pipe sizes 4 inches and larger.
- D. Provide butterfly valve with tapped lug body when used for isolating service.
- E. Solder or screw to solder adaptors for copper tubing.

2.3 IN-LINE STRAINER VALVES

- A. One piece configuration including union, strainer blow-down, P/T plug and ball valve.
- B. Strainer shall limit passage of particles greater than 250 microns, stainless steel screen, brass housing.
- C. Provide blowdown capability through accessory valving.

2.4 GATE VALVES

- A. Bronze, non-rising stem, inside screw, double wedge or disc, screwed ends.
- B. Iron body, bronze trim, rising stem, O.S. & Y., solid wedge flanged ends.

2.5 DRAIN VALVES

- A. Bronze compression stop with hose thread connection.

2.6 BALANCING VALVES WITH PRESSURE TAPS

- A. Bronze body, leaktight brass ball construction, combination balancing and shutoff.
- B. Calibrated nameplate with memory stop, leakproof meter connections, balancing adjustment knob.
- C. For GPM less than 0.5, provide valve specified for low flow.

2.7 PRESSURE RATINGS

- A. Unless otherwise indicated, use valves suitable for 200 psig and 250 degrees F. (water, oil, gas).
- B. Valve pressure rating to match pipe in which it is installed.

2.8 VALVE OPERATORS

- A. Provide suitable handwheels for gate, globe or angle, radiation and drain valves.
- B. For butterfly valves provide lever lock handle with toothed plate for shut-off service and infinitely adjustable handle with lock nut and memory stop for throttling service.
- C. Valves in insulated lines to have operators extended past insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install valves with stems upright or horizontal, not inverted.
- B. Install gate valves for shut-off and isolating service, to isolate equipment, part of systems or vertical risers.
- C. Install drain valves on low points of piping system and equipment.
- D. Install balancing valves as recommended by manufacturer's written instructions.

END OF HVAC VALVES

SECTION 15250

INSULATION

PART 1 - GENERAL

1.1 MECHANICAL GENERAL PROVISIONS

- A. The General Provisions of the Contract, including General, Supplementary, and Special Conditions apply to the Work specified in this Section.

1.2 WORK INCLUDED

- A. Duct Insulation
- B. Duct Insulation Accessories
- C. Pipe and Equipment Insulation
- D. Pipe and Equipment Insulation Accessories
- E. Pipe and Equipment Adhesives, Coatings and Sealants

1.3 QUALITY ASSURANCE

- A. Insulation materials, finishes, adhesives, cements, jackets and accessories shall be of the highest grade, shall be the standard products as manufactured by recognized companies, and shall comply with the fire hazard ratings set forth under general and specific requirements specified herein.

1.4 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this Section to the extent referenced. The publications are referenced to in the text by the basic designations only.
 - 1. American Society for Testing and Materials (ASTM) Publications.
 - 2. Underwriters' Laboratories, Inc. (UL) Standards.
 - 3. National Fire Protection Association (NFPA).

1.5 SUBMITTALS

- A. Submit shop drawings and samples in accordance with Section 15000, "MECHANICAL GENERAL PROVISIONS".
- B. Submitted shop drawings shall include complete material data and a list of materials proposed for this project. Indicate thickness of material for individual services. Submittal shall indicate compliance with Fire Hazard Ratings and shall give conductance and density of all materials.

1.6 JOB CONDITIONS

- A. Deliver material to job site in original unbroken factory packaging, labeled with manufacturer's name, density, and thickness.
- B. Perform work at ambient and surface temperature as recommended by the adhesive manufacturer.

1.7 FIRE HAZARD RATINGS

- A. Insulation materials, finishes, coatings, cements, jackets and other insulation accessories shall have composite or individual fire hazard ratings which conform to local, state and federal building codes which control building construction materials that may be used in the particular project location.
- B. Duct coverings, duct linings, panels used in duct systems, and other insulation accessories or piping insulation on pipes within air handling plenums or ducts used for air conditioning and ventilating systems shall comply with NFPA-90A, with fire hazard ratings not greater than the following:
 - 1. Insulations and accessories for the various systems and associated equipment shall be composed of materials which are non-combustible and provide a fire-resistive system of insulation which complies with the applicable code having jurisdiction. Generally, fire hazard ratings shall not exceed the following, except as noted:
 - a. Flame Spread Rating - 25 (No Exceptions)
 - b. Smoke Developed Rating - 50
 - c. Where permitted by applicable codes, standards, etc., a smoke developed rating greater than 50 may be considered, subject to approval by the Architect.
- C. Fire hazard ratings shall be as determined by NFPA-255, "Surface Burning Characteristics of Building Materials" or ASTM E84 or UL 723.
- D. Submittal data covering insulation materials and accessories shall include data sheets which shall positively indicate compliance with the above fire hazard ratings. Where questionable items are submitted, the manufacturer shall submit such additional data as may be requested by the Architect to establish compliance.
- E. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411-1982 at their rated temperature (not less than 250°F).

1.8 MISCELLANEOUS REQUIREMENTS

- A. Insulation materials herein specified shall be used subject to the manufacturer's temperature limitations and their compatibility with other materials.
- B. Each product container for finishes, adhesives cements, etc., shall bear UL label or shall otherwise indicate compliance with the above fire hazard ratings. Rates of application shall be not less than the rates specified in the manufacturer's published recommendations.

- C. Installation of all insulation work shall be executed by a qualified insulation Contractor who is thoroughly experienced in this particular type of work and who has adequate facilities and equipment for installation of all insulation work herein specified, and who is familiar with the requirements of the local code enforcing authority as to fire hazard ratings.
- D. Types of insulation, thickness, jackets, finishes, etc., shall be as specified in the Insulation Schedules and Charts for the various types of services listed.
 - 1. The finished installation shall present a neat and acceptable appearance with all jackets smooth, with all joints, laps, seals, etc., properly made and with all vapor barriers sealed and intact.
- E. Unless otherwise herein specified or shown on the drawings, the terms "finished spaces" or "exposed areas" as used herein are intended to include all areas except:
 - 1. Furred spaces.
 - 2. Pipe and duct shafts which are not accessible for servicing or maintenance operations.
 - 3. Spaces above furred and suspended ceilings.
 - 4. Unfinished attics.
- F. Unless otherwise specified or shown on the drawings, the word "concealed" is intended to include all areas except "finished spaces" or "exposed areas" as defined above.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Fiberglass Insulation
 - 1. Certain-Teed Products Corporation
 - 2. Manville Corporation
 - 3. Owens-Corning Fiberglas
 - 4. Knauf
- B. Flexible Elastomeric Insulation
 - 1. Armstrong
 - 2. Halstead
 - 3. Rubatex
- C. PVC Fitting Covers
 - 1. Zeston (Manville)

2. Foster Products Corp.
 3. Proto
- D. Accessories
1. Foster Products Corp. (FPC)
 2. Chicago Mastic (CM)
 3. Childers
 4. 3M
 5. St. Clair Rubber (SCR)
 6. Vimasco (V)
 7. Baldwin-Erber-Hill (BEH)
- E. These specifications, for purpose of brevity and selection, may mention only one manufacturer's product which shall not preclude the use of equal products of other manufacturers as approved by the Architect.

2.2 MATERIALS

A. Duct Insulation

1. Faced flexible glass fiber duct insulation shall have a fire retardant, reinforced foil/kraft vapor barrier facing and shall be equal to Owens-Corning Fiberglass Faced Duct Wrap Series 100. Insulation shall have a nominal thickness of 2 inches and a thermal conductivity of approximately 0.27 at 75 degrees F.
2. Faced rigid glass fiber duct insulation shall have a fire retardant, reinforced foil/kraft vapor barrier facing and shall be equal to Owens-Corning Fiberglass 700 series. Insulation shall have a nominal thickness of 1-1/2 inches, a thermal conductivity of approximately 0.22 at 75 degrees F, and a density of 3 pounds per cubic foot.
3. Coated flexible glass fiber duct liner shall be equal to Owens-Corning Aeroflex PLUS duct liner. Liner shall have a nominal thickness of 1 inch, a thermal conductivity of approximately 0.28 at 75 degrees F, and a density of 1.5 pounds per cubic foot. Coating shall be a black pigmented, fire-resistant coating on the side in contact with the air stream.
4. Ducts, plenums and housings for air handling equipment having internal liners are not to be insulated on the exterior surfaces. Fire dampers shall be externally insulated. Generally, all medium velocity supply air ductwork will be externally insulated unless noted otherwise.
5. Where factory fabricated housings for air handling equipment are specified, they will generally be factory insulated and no exterior insulation will be required. However, where no factory insulation or liners are provided they shall be insulated as shown in the Insulation Schedules and Charts.

B. Duct Equipment Accessories

1. Duct Jackets

- a. Where ASJ jackets are specified or scheduled herein, the use of alternative jackets will be permitted subjected to the following conditions:
- (1) The jackets shall, in finished areas, present a final finished surface which is equal to that of the ASJ jacket as to duty and appearance.
 - (2) The alternative jacket shall perform the same duty as the ASJ jacket, except that hot ductwork will not require the vapor barrier incorporated in the ASJ jacket.
 - (3) In order to avoid the substitution of inferior or inappropriate jackets, all alternative jackets will be subject to review and approval by the Architect.
 - (4) Samples of alternative jackets shall be submitted when requested by the Architect.
- b. Faced flexible and rigid fiberglass duct insulation for cold ducts shall have a factory applied finish jacket equal to Owens-Corning Fiberglass FRK fire retardant, vapor barrier, foil laminated to reinforced Kraft facing.

2. Duct Adhesives, Coating and Sealants

- a. Adhesives, coatings and sealants shall be compatible with other insulation materials as recommended by the manufacturer. The following is a partial list of services and the corresponding material to be used. Other equivalent products as recommended by the manufacturer may be used, subject to approval of the Architect.

<u>SERVICE</u>	<u>MATERIAL</u>
For gluing laps of ASJ jackets	FPC 85 - 20
For securing flexible fiberglass duct insulation to ducts	FPC 85 - 20
For sealing vapor barriers	FPC 30 - 35
For sealing joints in Fiberglas ASJ sealing tape	ASJ Joint

3. Duct Accessories and Fastening Materials

- a. Staples shall be of the outward clinching type of corrosion resisting steel. Use of staples shall be limited to laps of jackets on flexible blanket duct insulation and other materials and locations as approved by the Architect.

C. Pipe and Equipment Insulation

1. Molded glass fiber insulation for pipes in finished and concealed areas shall be equal to Owens-Corning Fiberglass ASJ/SSL-II pipe insulation with all service jacket, with SSLII self sealing system on all cold lines. Insulation shall have a density of approximately 4.0 pounds per cubic foot and a thermal conductivity of not more than 0.23 at 75 deg. F mean temperature, and shall be suitable for surfaces which reach 450 deg. F.
2. Flexible elastomeric insulation for pipes shall be closed cell type and shall be equal to Armstrong AP Armaflex pipe insulation. Insulation shall have a thermal conductivity of not more than 0.27 at 75 degrees F mean temperature.
3. Factory Applied Pipe Insulation
 - a. Hot water piping: Fine glass fiber insulation. "K" value at 75 degrees F maximum 0.25 Btu/in./sq. ft./degree F/hr.
4. Pipe and Equipment Jackets
 - a. Where ASJ jackets are specified or scheduled herein, the use of alternative jackets will be permitted subject to the following conditions.
 - (1) The jackets shall, in finished areas, present a final finished surface which is equal to that of the ASJ jacket as to duty and appearance.
 - (2) The alternative jacket shall perform the same duty as the ASJ jacket, except that hot piping and hot equipment will not require the vapor barrier incorporated in the ASJ jacket.
 - (3) In order to avoid the substitution of inferior or inappropriate jackets, all alternative jackets will be subject to review and approval by the Architect.
 - (4) Samples of alternative jackets shall be submitted when requested by the Architect.
5. Factory Applied Piping Insulation Jackets
 - a. Hot water and steam piping: Standard general purpose jacket.
6. Pipe and Equipment Adhesives, Coatings and Sealants.
 - a. Adhesives, coatings and sealants shall be compatible with other insulation materials as recommended by the manufacturer. The following is a partial list of services and the corresponding material to be used. Other equivalent and equal products as recommended by the manufacturer may be used, subject to approval of the Architect.

<u>SERVICE</u>	<u>MATERIAL</u>
For gluing laps of ASJ jackets	FPC 85 - 20
For sealing vapor barriers	FPC 30 - 35
Fittings, valves, flanges for chilled water piping	FPC 30 - 35 & 30 - 42
For sealing joints in Fiberglass ASJ sealing tape	ASJ joint

7. Pipe and Equipment Accessories & Fastening Materials

- a. Staples shall be of the outward clinching type of corrosion resisting steel. Use of staples shall be limited to laps of jackets on pipe and equipment insulation and other materials and locations as approved by the Architect.
- b. Pre-molded pipe fitting covers shall be one piece PVC sheet material, off white color and shall be equal to Zeston 2000. Use shall be subject to the manufacturer's limitations.

PART 3 - EXECUTION

3.1 PREPARATION

A. Duct Insulation

1. Surfaces to be insulated shall be clean, dry and free from rust and scale when insulation is being applied. Insulation shall be dry at the time of installation and before and during the process of finish application.
2. Insulation shall not be applied before ducts have been proved tight at the specified test pressures.
3. Round flexible connections to air distribution devices shall be externally insulated with flexible, vapor barrier type insulation. Where fire dampers are installed in externally insulated ducts, they shall be externally insulated same as specified for externally insulated ducts. Coordinate Insulation Work with that of ductwork to ensure external insulation overlaps internal liner at least 2 inches.
4. Surfaces of insulation shall be smooth, even and true to line with jackets drawn tight and smoothly secured. Scrap pieces of insulation shall not be used where a full length section will fit.
5. The tops of all diffusers shall be insulated in the same manner as connecting ductwork to prevent condensation.
6. Insulation shall be continuous through non-rated walls, partitions and floors unless otherwise noted.
7. Only experienced mechanics, skilled and trained in the insulation trade, shall be used for application of the insulation materials.

B. Factory Applied Pipe Insulation and Jacket

1. Obtain instruction from the manufacturer in the application of field applied joint insulation. Manufacturer to certify in writing that contractor has received such instruction.

3.2 INSTALLATION

A. Duct Insulation

1. Faced Flexible Glass Fiber

- a. Insulation shall be tightly wrapped on the ductwork with all circumferential joints butted and longitudinal joints lapped 2 inches and stapled. Joints shall be sealed with approved adhesive. Adhere insulation to ducts with 4 inch wide strips of an approved bonding adhesive, at 12 inches on center. For ducts 24 inches or greater in width, secure insulation to bottom of ductwork with mechanical fasteners spaced at not greater than 18 inches on center.
- b. Insulation shall be butted with facing overlapping all joints at least 2 inches and sealed with approved fire retardant vapor barrier adhesive. Breaks, punctures, pin penetrations in facing shall be sealed with vapor barrier tape and vapor barrier adhesive. Joints shall be taped with vapor barrier tape and vapor barrier adhesive where so recommended by the manufacturer's published installation instructions.

2. Faced Rigid Glass Fiber

- a. Insulation shall be cut and applied using mechanical fasteners. Fasteners shall be located not less than 3 inches from each edge or corner of the board. Pin spacing along the duct shall be no greater than 12 inches on center. Circumferential joints and longitudinal joints shall be sealed with a pressure sensitive joint sealing tape to match the insulation facing.
- b. Insulation shall be butted with facing overlapping all joints at least 2 inches and sealed with approved fire retardant vapor barrier adhesive. Breaks, punctures, pin penetrations in facing shall be sealed with vapor barrier tape and vapor barrier adhesive. Joints shall be taped with vapor barrier tape and vapor barrier adhesive where so recommended by the manufacturer's published installation instructions.
- c. Exterior insulation shall be covered with two coats of weatherproof coating as recommended by the insulation manufacturer over the entire insulation surface. Embed a layer of glass cloth in between coats.

B. Pipe and Equipment Insulation

1. General

- a. Installation of all Insulation Work shall be executed by a qualified insulation contractor who is thoroughly experienced in this particular type of work and who has adequate facilities and equipment for installation of

all insulation work herein specified, and who is familiar with the requirements of the code enforcing authority as to fire hazard ratings.

- b. Types of insulation, thickness, jackets, finishes, etc., shall be as specified in the Insulation Schedule and Charts for the various types of services listed.
- c. The finished installation shall present a neat and acceptable appearance with all jackets smooth, and with all vapor barriers sealed and intact.
- d. Surfaces to be insulated shall be clean, dry and free from rust and scale when insulation is being applied. Insulation shall be dry at the time of installation and before and during the process of finish application.
- e. Insulation shall not be applied before pipe lines have been proved tight at the specified test pressures.
- f. Valves, flanges and fittings, except threaded unions in hot water piping, shall be insulated to the same thickness as the pipe insulation.
- g. The insulation at threaded unions in hot water piping shall be tapered and terminated with cement and glass lagging cloth and lagging adhesives. Insulation shall be continuous through non-rated walls, partitions and floors unless otherwise noted. Refer to the heading FIRESTOPPING AND SMOKESTOPPING.
- h. Insulate exterior surfaces of all anchors and guides for chilled water piping system.
- i. A complete moisture and vapor barrier shall be installed wherever insulation terminates against pipe saddles, hangers or other projections through insulation and in contact with cold surfaces for which a vapor seal is specified. Pipe saddles shall be filled with insulation, and shall be vapor sealed on cold piping.
- j. Nameplates, ASME and other inspection stamps on hot equipment shall not be covered. Metal covers shall be furnished and installed at manhole and thermostat openings, nameplates and stamps with insulation neatly finished thereto.

2. Molded Glass Fiber Pipe Insulation

- a. Insulation of this type used with copper tubing shall be molded to separate dimensional standards than those of steel pipe.
- b. In finished areas, molded glass fiber insulation or fiberglass pipe wrap shall be used to insulate piping where commercially available sizes can be used.
- c. Fittings on pipe lines in finished and concealed areas shall be covered with flexible fiberglass insulation inserts and premolded pipe fitting covers equal to Zeston 2000 fitting covers where sizes are available. Insulation shall fill the fitting cover and shall not leave any void spaces. The use of premolded pipe fitting covers shall be subject to the limitations set forth

by the manufacturer. For sizes where premolded fitting covers are not available use miter-cut segments of molded pipe insulation, wired in place, with all joints sealed with adhesive and smoothed out with a coat of insulating cement. Flanges, strainers, automatic and manual valves shall be insulated with mitered segments of pipe insulation wired in place with joints and raw edges sealed with adhesive and smoothed out with a coat of insulating cement.

- d. On cold pipes, the fittings shall be finished with two coats of an approved vapor barrier mastic, reinforced with glass cloth extending 2 inches onto adjacent pipe insulation. Where premolded pipe fitting covers (Zeston 2000) are used, the vapor barrier shall lap over and onto the adjacent pipe insulation. Hot pipes shall be finished in a similar manner, except the mastic need not be of the vapor barrier type.

3. Factory Applied Pipe Insulation

- a. Apply joint insulation per manufacturer's instructions.
- b. Inspect insulation before installation to ensure material integrity.

4. Factory Applied Pipe Insulation Jackets

- a. Apply joint jacket per manufacturer's instructions.
- b. Inspect insulation jacket before installation to ensure material integrity.

3.3 FIELD QUALITY CONTROL

Visually inspect to ensure that materials provided conform to specifications. Inspect installations progressively for compliance with requirements.

A. Air Distribution Systems

Obtain written approval of systems under Section 15030, "ADJUSTING, BALANCING AND SYSTEM TESTING" before applying field insulation to air distribution systems.

B. Piping Systems

Obtain Contracting Officer's written approval of HVAC water distribution systems under Section 15030, "ADJUSTING, BALANCING AND SYSTEM TESTING" before applying field-applied insulation to HVAC water distribution systems. At Contractor's option and with Contracting Officer's written approval, piping systems may be insulated before systems are tested, adjusted, and balanced (TAB'd). Piping insulation shall terminate immediately adjacent to each flow control valve, automatic control valve, or device. For chilled water and chilled-hot water piping systems, seal ends of pipe insulation and space between ends of pipe insulation and piping with waterproof vapor barrier seating. After systems are TAB'd, insulate control valves and devices.

3.4 SCHEDULE

A. Duct Insulation

Service	Type Insul	Finishes		Notes
		Concealed Areas	Finished Areas	
Concealed Interior Low Pressure A.C.	Flexible Glass Fiber	FRK Vapor Barrier	FRK Vapor Barrier	
Supply Outside & Mixed Air & Fire Dampers	Flexible Glass Fiber	FRK Vapor Barrier	FRK Vapor Barrier	
Exterior Ductwork	Rigid Glass Fiber	FRK Vapor Barrier	FRK Vapor Barrier	
** Low Pressure Supply & Return Outside & Mixed Air In Exposed Locations	Rigid Glass Fiber	FRK Vapor Barrier	FRK Vapor Barrier	
Return	* Flexible Glass Fiber	FRK Vapor Barrier	FRK Vapor Barrier	
Transfer Ducts as Indicated	Duct Liner			
High Pressure Supply Duct	Consult duct fabrication requirements for lined ductwork, otherwise as noted or like supply ductwork			

* Unless otherwise noted on drawings or specifications.

** Also applies to all exterior insulated ducts conveying conditioned air thru heated only spaces including exhaust, return and relief air systems.

B. Pipe Insulation

Chilled Water	Rigid Glass Fiber A/1	ASJ/SSL-II	ASJ/SSL-II
Heating Hot Water	Rigid Glass Fiber A/2	ASJ/SSL-II	ASJ/SSL-II
Domestic H.W. & H.W. Return	Rigid Glass Fiber A/3	ASJ/SSL-II	ASJ/SSL-II
Domestic C.W.	Rigid Glass Fiber A/6	ASJ/SSL-II	ASJ/SSL-II
Roof Drain Sumps (including overflow) & Horizontal Rain Leaders (including overflow)	Rigid Glass Fiber A/7 & 8	ASJ/SSL-II	ASJ/SSL-II
Interior A.C. Condensate Drain & Water Cooler Drain	Rigid Glass Fiber A/9	ASJ/SSL-II	ASJ/SSL-II
*Floor Drains Plus 20' of drain pipe from F.D.	Rigid Glass Fiber A/10	ASJ/SSL-II	ASJ/SSL-II
**Refrigerant Suction	Rigid Glass Fiber A/11	ASJ/SSL-II	ASJ/SSL-II

*Note: Applies to floor drains above first floor receiving cold condensate.

**Note: Refrigerant suction piping does not require insulation specified herein if preinsulated piping is used.

Note: Flexible elastomeric pipe insulation may be used in lieu of rigid glass fiber on A.C. condensate and refrigerant suction.

NOTE: Provide corrugated or smooth aluminum jacket for all insulated pipes 0'-0" to 6'-0" above finished floors and mezzanines for insulation protection.

CHART A
PIPE INSULATION THICKNESS BASED ON RIGID GLASS FIBER

Refer Line No.	Piping System	System Temp. Range Deg. F	Insulation thickness in inches for Pipe Sizes (R=4.0 - 4.6)				
			1” & Less	1-1/4” -2”	2-1/2” -4”	5-6”	8” or larger
	Cooling Systems						
1**	Chilled Water	42-55	1-1/2	1-1/2	1-1/2	2	2
	Domestic, Hot Water And Steam Systems						
2	Heating Hot Water	140-200	1-1/2	1-1/2	1-1/2	2	2
3	Domestic Hot Water & H.W. Return	110-140	1	1	1-1/2	1-1/2	1-1/2
4	Domestic Cold Water	48-80	1/2	3/4	1	1	1
5	Interior A.C. Condensate Drain & Water Cooler Drain	All	1/2	3/4	--	--	--
6 *	Floor Drains	All	--	1/2	1/2	--	--
7	Refrigerant Suction	All	1/2	1/2	--	--	--

* NOTE: Applies to floor drains above the first floor receiving cold condensate.

** NOTE: Exterior chilled water piping insulation thickness shall be 1/2 inch greater than insulation thickness listed.

END OF INSULATION

SECTION 15400

PLUMBING

PART 1 - GENERAL

- 1.1 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
- A. American National Standards Institute (ANSI) Publications
 - B. American Society for Testing and Materials (ASTM) Publications
 - C. American Society of Sanitary Engineers (ASSE) Publications
 - D. American Water Works Association (AWWA) Publications
 - E. Cast-Iron Soil Pipe Institute (CISPI) Publications
 - F. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Publications
 - G. Plumbing and Drainage Institute (PDI) Publications
 - H. ICC International Plumbing Code 2003
 - I. Virginia Uniform Statewide Building Code (VUSBC)
- 1.2 GENERAL REQUIREMENTS: Section 15000, "Mechanical General Provisions", applies to this section, with the additions and modifications specified herein.
- 1.3 DESCRIPTION OF WORK: The work includes [modifying existing and] providing new plumbing systems and related work. The work also includes providing roughing-in and making final plumbing connections to equipment furnished under other sections of this specification. Provide each system complete and ready for operation. Plumbing systems including fixtures, equipment, materials, installation, workmanship, examination, inspection, and testing shall be in accordance with the ICC International Plumbing Code, except as modified herein. In the Plumbing Code referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for the word "should" wherever it appears. Capacity of equipment shall be not less than that indicated. Plumbing systems shall include all water and sanitary piping[buried and above ground except water and sanitary piping more than 5 feet outside of the building walls is specified in Division 2.
- 1.4 SUBMITTALS
- A. Submit shop drawings in accordance with 15000, "MECHANICAL GENERAL PROVISIONS".
 - B. Manufacturer's Data:
 - 1. Pipe and fittings
 - 2. Valves
 - 3. Plumbing fixtures
 - 4. Water heaters

5. Pipe supports (hangers)
6. Pumps
7. Gages and thermometers
8. Strainers
9. Drains
10. Water hammer arresters
11. Backflow preventers
12. Insulation kits for barrier free fixture fittings

C. Shop Drawings:

1. Access panels

D. Certificates of Compliance:

1. Pipe and fittings
2. Valves
3. Water flushing volume of flushometer and urinal combination
4. Water flushing volume of flushometer and water closet combination
5. Backflow preventers

E. Certified Data:

1. Water heaters
2. Pump test curves
3. Backflow preventers

F. Operation and Maintenance Manuals:

1. Water heaters
2. Pumps

G. Posted Operating Instructions:

1. Water heaters
2. Pumps

- 1.5 INSULATION: Insulate equipment and piping under this section as specified in Section 15250, "Insulation", except as specified herein for barrier free accessible fixtures and fittings.
- 1.6 FIELD PAINTING: Provide under Section "Field Painting".
- 1.7 FLASHING: Provide under Section "Flashing and Sheet Metal".
- 1.8 ELECTRICAL REQUIREMENTS: Furnish motors, controllers, contactors, and starters with their respective pieces of equipment. Motors, controllers, contactors, and starters shall conform to and shall have electrical connections provided under Division 16. Controllers and contactors shall have a maximum of 120-volt control circuits, and auxiliary contacts for use with the controls furnished. Disconnect switches shall be provided under Division 16 unless specified in this section as integral with equipment. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section.

PART 2 - PRODUCTS

- 2.1 DWV (DRAIN, WASTE, AND VENT) PIPING: Fittings shall be long radius fittings, except fittings in vent piping may be short radius fittings. Minimum size piping shall be 2 inches for buried piping and 1.5 inches for aboveground piping.
- A. Buried Piping: Buried piping includes piping up to but not more than 6 inches above ground or floor slab on grade.
1. Cast-Iron Hubless Pipe and Fittings: CISPI 301 with CISPI 310 coupling joints.
 2. Cast-Iron Hub and Spigot Pipe and Fittings: ASTM A 74 with ASTM C 564 rubber compression gasket joints, or caulked and leaded joints.
 3. Plastic Pipe: PVC, (DWV) Schedule 40, ASTM D2665, or ABS Sewer Pipe, ASTM D2661 may be installed as permitted by code. PVC and ABS pipe shall not be installed in locations where temperatures will be above 140 degrees F.
- B. Aboveground Piping:
1. Cast-Iron Hubless Pipe and Fittings: CISPI 301 with CISPI 310 coupling joints.
 2. Cast-Iron Hub and Spigot Pipe and Fittings: ASTM A 74 with ASTM C 564 rubber compression gasket joints, or caulked and leaded joints.
 3. Plastic Pipe: PVC, (DWV) Schedule 40, ASTM D2665 or ABS Sewer Pipe, ASTM D2661 may be installed as permitted by code.
 4. Copper Tubing: ASTM B 306, with ANSI B16.23, ANSI B16.29, or ANSI B16.32 solder joint fittings using ASTM B 32, 95-5 tin-antimony solder.
 5. Steel Pipe: ASTM A 53 or ASTM A 120, Schedule 40, hot-dip galvanized, threaded end connections; with ANSI B16.12 hot-dip galvanized threaded fittings.
- C. Cleanouts: ANSI A112.36.2; provide threaded bronze or thermoplastic cleanout plugs.
1. Floor Cleanouts: Provide cast-iron floor cleanout with flange, brushed stainless steel or brushed nickel rim and scoriated floor plate with CO cast in the plate. Secure floor plate with countersunk screws for installation flush with finished floor.
 2. Wall Cleanouts: Provide brushed stainless steel or brushed nickel cover plate and secure to cleanout plug with countersunk screw.
 3. Cleanouts Exterior to Buildings: Provide cast-iron cleanouts and countersunk plugs. Provide 24- by 24- by 4-inch thick concrete slab with top 1.0 inch above grade with cleanout located in center of slab. Provide cast-iron cleanout box with cover.
- D. Drains: ANSI A112.21.1M; provide cast-iron drains and clamping rings for use with membrane waterproofing.
1. Flush Strainer Floor Drains: Provide with double drainage flange, perforated or slotted brushed stainless steel or brushed nickel strainer, adjustable collar, and P-trap. Provide with trap primer connection where indicated.

2. Automatic Trap Primer: Provide automatic floor drain trap primer with integral backflow preventer and vacuum breaker on all floor drains. Precision Plumbing Products, Inc. or approved equal.
 3. Mechanical Room and Area Drains: Provide with heavy-duty cast-iron grate and sediment bucket.
- E. Acid Resistant DWV Pipe, Fittings and Couplings
1. Acid-resistant polypropylene piping shall be manufactured to Schedule 40 P.E. pipe dimensions, for above ground, and Schedule 80 P.E. pipe dimensions for below ground. Pipe shall be fire retardant, to be supplied in 10 ft. lengths. Pipe shall be cylindrical and straight to meet tolerances in accordance with ASTM D 2447-74. Pipe shall be factory grooved for mechanical joint systems and plain end for socket fusion systems. Material shall conform to ASTM D 4101.
 2. Acid-resistant fittings shall be manufactured to Schedule 40 P.E. pipe dimensions of fire retardant polypropylene. Fittings shall conform to tolerances in ASTM D 3311. Material to meet ASTM D 4101.

2.2 DOMESTIC WATER PIPING

- A. Buried Piping and Aboveground Piping:
1. Copper Tubing: ASTM B 88, Type K, with ANSI B16.18 or ANSI B16.22 solder joint fittings using ASTM B 32, grade Sn 96 tin-silver solder and flux containing not more than 0.2 percent lead, or with ANSI B16.26 flared joint fittings. ASTM B 88, Type L, shall be provided for aboveground piping.
- B. Water Valves: Provide valves suitable for minimum of 125 psig and minimum of 180 degrees F hot water in accordance with MSS SP-80-79. Valves shall have threaded end connections with a union on all but one side of the valve, or solder end connections for connections between bronze valves and copper tubing. Copper alloy and bronze valve body shall be ASTM B 61 or ASTM B 62 copper alloy. Ball valves may be provided in lieu of gate valves.
1. Acceptable Manufacturers: Valves shall be of one manufacturer for each type of valve. Where valve manufacturers are not specifically indicated below, they shall be one of the following: Crane, Jenkins, Stockham, Nibco, Scott, Grinnel or Red & White.
 2. Valve Connections: Provide valves suitable to connect to adjoining piping as specified for pipe joints. Use line size valves.
 3. Ball Valves: Ball valves used in connection with piping 2 inches in size and smaller, shall have screwed or sweat ends, bronze body, bronze ball and resilient seal. Valve shall be serviceable from either top or end without removing piping. For water service, valves shall be designed for 200 lbs. WOG and 250 degrees F.
 4. Hose Bibbs: Provide angle type copper alloy globe valve with lock-shield and handwheel. Inlet shall have internal threads. Outlet shall have vacuum breaker with 0.75-inch external hose threads.

5. Reduced Pressure Backflow Preventers: Provide ASSE 1013 approved reduced pressure backflow preventers where indicated, as manufactured by Watts 900 Series, or equal by Febco or Conbraco. Provide with air gap fitting piped to nearest floor drain or other approved location.
6. Check Valves: Check valves in piping 2 in. and smaller shall be bronze body, renewable bronze disc screwed or sweat ends, designed for 125 lbs. steam pressure.
7. Vacuum Breakers:
 - a. Hose outlet vacuum breakers - 3/4 in. size, stainless steel and cast brass construction, plated as faucet to which attached, equal to Watts #NF-8.
 - b. Other vacuum breakers - angle, pressure type, brass body, equal to Watts 288A or Nibco 715. Vacuum breakers on chrome-plated piping similarly plated.
8. Vacuum Relief Valves: Bronze body construction with silicone disc equal to Watts model 36A.
9. Pressure Relief Valves: Bronze or cast-iron body, with test lever, and shall be suitable for the intended service.
10. Manual Balance Valves (Hot Water Recirculation System):

Flow Control Balancing Valves: Copper alloy body, copper alloy or stainless internal working parts, and integral pointer that indicates the degree of valve opening. Valves shall be suitable for 125 psig at 190 degrees F hot water. Valve shall function as a service valve when in fully closed position. Valve body shall have factory-installed tapings for differential pressure meter connections for verification of pressure differential across valve orifice. Meter connections shall have positive check valves or shutoff valves. Each valve shall have metal tag showing the gallons per minute flow for each differential pressure reading.
- C. Dielectric Connections: Provide at connections between copper and ferrous metal piping materials. ASTM F 441, Schedule 80, CPVC threaded pipe nipples, 4-inch minimum length, may be provided for dielectric connections in pipe sizes 2 inches and smaller.
- D. Water Hammer Arresters: Expansion bellows type with pressurized compression chamber; ANSI A112.26.1, OR ASSE 1010.
- E. Wall Hydrant: Wall hydrant, exposed type with vacuum breaker/backflow preventer, wall mounted, automatic draining, freezeproof, key operated, polished brass finish on brass casting. Woodford model 65 or approved equal by Zurn or Josam.
- F. Pressure Gauge: Provide single style pressure gage for water with 4.5-inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range suitable for the intended service.
- G. Thermometers: Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 5-inch diameter dial with glass face gasketed within the case;

accuracy within 2 percent of scale range. Provide scale range suitable for the intended service.

2.3 EXPANSION TANK: Drawn steel tank with butyl diaphragm, 150 psi max. working pressure, in-line type, field adjustable air charge, suitable for use in potable domestic cold water systems.

2.4 GAS PIPING

A. Refer to Section 15355, "Fuel Gas Piping".

2.5 MISCELLANEOUS PIPING MATERIALS

A. Pipe Nipples: Copper alloy for use in copper tubing and hot-dip galvanized Schedule 80 steel pipe for use in steel piping.

B. Escutcheon Plates: Provide one piece or split hinge type metal plates for piping passing through floors, walls, and ceilings in exposed spaces. Provide chromium-plated finish on plates in finished space. Provide paint finish on plates in unfinished spaces. Securely anchor plates in place with set screws or other approved positive means.

C. Pipe Sleeves: Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

1. Sleeves in Masonry and Concrete: Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth. PVC sleeves shall not be used in walls adjacent to plenum spaces.

2. Sleeves Not in Masonry and Concrete: Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves. PVC sleeves shall not be used in walls adjacent to plenum spaces.

D. Pipe Supports (Hangers): Provide MSS SP-58 and MSS SP-69, Type 1, Type 7, or Type 12, of the adjustable type, except as indicated or specified herein. Provide Type 40 insulation protection shields for insulated piping. Provide steel support rods. Provide nonmetallic, hair felt, or plastic piping isolators between copper tubing and the hangers. Provide flat wide band hangers for un-insulated plastic piping.

E. Access Panels: Provide factory prefabricated and primed steel access panels including 16-gage steel frame with a hinged or snap-on 14-gage steel cover with spring-catch or turn-latch. Provide panel with factory-primed rust-inhibitive paint. the wide-leg or flange of the frame section shall be perforated or shall extend into expanded metal wings to provide a key for plaster. Size and furnish panels under this section to provide proper access to concealed valves and control devices; install panels under the appropriate

section of this specification.

- 2.6 **FIXTURES, FITTINGS, ACCESSORIES, AND SUPPLIES:** Provide control-stop valves in each supply to each fixture. The finish of fittings, accessories, and supplies exposed to view shall be chromium-plated. Zincoalloy or plastic handles will not be permitted for faucets and valves. Provide special roughing-in for wheelchair fixtures. Exposed traps, supplies and stop valves at barrier free fixtures shall be insulated with ANSI and ADA approved, vinyl molded insulation with nylon fastener kits, painted as directed by the Architect. Fixtures shall be as manufactured by American Standard, Kohler or Eljer. Model numbers provided are to indicate desired quality and style, others will be considered if approved equal by the Architect/Engineer.

- A. Water flow rates and water consumption for fixtures shall be as follows:

Water closets:	1.6/1.1 GPF per flushing cycle
Urinals:	.125 GPF per flushing cycle
Lavatories:	0.5 GPM at 80 psi
Sinks:	2.2 GPM at 60 psi

Refer to fixture plates for selections of Basis of Design.

2.7 **DOMESTIC WATER HEATERS (ELECTRIC)**

- A. Storage Tank Type: UL 174, electric water heaters, glass-lined steel tanks, high efficiency type insulated with polyurethane foam insulation, replaceable anodes, conforming to ASHRAE 90A requirements, with adjustable range thermostat to allow hot water settings between 110 and 160 degrees F of size and capacity as shown on the drawings, as manufactured by State or approved equal. Provide posted operating instructions for water heaters. Water heaters with input ratings greater than or equal to 58 kw; or a storage capacity greater than or equal to 120 gallons shall be constructed in accordance with ASME standards and bear the ASME stamp.
- B. Furnish and install a drain pan under water heater. Drain pan shall be not less than 1-1/2" deep and shall be of sufficient size and shape to receive all dripping or condensate from the tank or water heater. The pan shall be drained by an indirect waste pipe having a minimum diameter of 1 inch or the outlet diameter of the required relief valve whichever is larger. The pan drain shall extend full size and terminate over a suitably located indirect waste receptor, floor drain or extend to the exterior of the building and terminate not less than 6 inches nor more than 24 inches above finished grade.
- C. Heater shall be covered by a 10 year limited commercial warranty against tank failure.

- 2.8 **PUMPS:** Submit for approval the manufacturer's certified characteristic performance curve for the impeller size to be furnished. Select the pump so that the operating point on the characteristic performance curve for the impeller size to be furnished will be to the left. (shut-off side) of and not more than 5 percent below the point of maximum efficiency for the impeller to be furnished.

- A. Inline Water Pumps: Capacity as indicated on the drawings.
- B. Submersible Sump Pumps: Provide factory assembled and tested submersible type pumps for operation under water. Pump shall be complete with cast-iron casing, bronze impeller, stainless steel shaft, sealed heavy-duty ball bearings, water-cooled hermetically-sealed motor, built-in automatic reset thermal protection, mercury float switch, and waterproof three-conductor cables and grounding plug.

PART 3 - EXECUTION

3.1 **INSTALLATION:** Installation of plumbing systems including fixtures, equipment, materials, and workmanship shall be in accordance with the ICC International Plumbing Code, except as modified herein. When fixtures require both hot water and cold water supplies, provide the hot water supply to the left of the cold water supply. Plastic piping shall not penetrate fire walls.

A. **Threaded Connections:** Jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread tape, pipe cement and oil, or PTFE powder and oil; apply only on male threads. Provide exposed ferrous pipe threads with one coat of primer applied to a minimum dry film thickness of 1.0 mil.

B. **Pipe Supports (Hangers):** In accordance with the ICC International Plumbing Code or MSS-SP-69. Provide additional supports at the concentrated loads in piping between supports, such as for inline water pumps and flanged valves.

1. **Piping to Receive Insulation:** Provide temporary wood spacers between the insulation protection shield and the pipe in order to properly slope the piping and to establish final elevations. Temporary wood spacers shall be of the same thickness as the insulation to be provided under Section [15250] [23 07 00], "Insulation".

2. **Maximum Spacing Between Supports:**

a. **Vertical Piping:** Support metal piping at each floor, but at not more than 10-foot intervals. Support plastic piping at 4 foot intervals.

b. **Horizontal Piping:** Support cast-iron piping at 5-foot intervals, except for pipe exceeding 5-foot length, provide supports at intervals equal to the pipe length but not exceeding 10 feet. (Support plastic piping at 4-foot intervals.) Support steel piping and copper tubing as follows:

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	4	6
Steel Pipe	12	12	12	12	12	12	12	12
Copper Tube	6	6	10	10	10	10	10	10

3.2 **NAMEPLATES:** Provide laminated plastic nameplates for equipment, gages, and valves; stop valves in supplies to fixtures will not require nameplates. Laminated plastic shall be 0.125-inch thick melamine plastic, black with white center core. Surface shall be a matte finish. All corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be 1.0 inch by 2.5 inches. Lettering shall be minimum of 0.25-inch high normal block lettering. Key the nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule. Each inscription shall identify its function. Equipment nameplates shall show the following information.

A. **Manufacturer, type, and model number**

B. **Capacity or size**

- C. System in which installed
 - D. System which it controls
- 3.3 DISINFECTION: Disinfect the new water piping in accordance with AWWA C651 or C652. Fill the piping systems with solution containing minimum of 50 parts per million of available chlorine and allow solution to stand for minimum of 24 hours. Flush the solution from the systems with clean water until the chlorine is purged from the system.
- 3.4 FIELD TESTING: Before final acceptance of the work, test each system as in service to demonstrate compliance with the contract requirements. Perform the following tests in addition to the tests specified in the ICC International Plumbing Code, except as modified herein. Correct all defects in the work provided by the Contractor, and repeat the tests until the work is in compliance with contract requirements.
- A. Domestic Water Piping: Before insulation is applied, hydrostatically test each piping system at not less than 100 psig with no leakage or reduction in gage pressure for 2 hours. Test the connection of new piping to existing piping at system operating pressure.
 - B. DWV Piping: Before the installation of fixtures, cap the ends of each system, fill the piping with water to the roof, and allow to stand until a thorough inspection has been made. After the plumbing fixtures have been set and their traps filled with water, subject the entire sanitary system to a final air pressure test of not more than 1.0 inch of water column. The entire system must be proven absolutely tight under such test. Test the connection of new DWV piping to existing DWV piping by flowing no less than 5 gpm of water for 5 minutes through the system and visually inspecting for leaks.
 - C. Refer to Section 15355, "Fuel Gas Piping".

END OF PLUMBING

SECTION 15403
MEDICAL GAS SYSTEM

PART 1 - GENERAL

- 1.1 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
- A. American National Standards Institute (ANSI) Publications
 - B. American Society for Testing and Materials (ASTM) Publications
 - C. American Welding Society (AWS) Publications
 - D. Compressed Gas Association (CGA) Publications
 - E. The Copper Development Associations (CDA) Publication
 - F. Manufacturer's Standardization society of the Valves and Fittings Industry (MSS) Publications
 - G. National Fire Protection Associations (NFPA) Publications
- 1.2 GENERAL REQUIREMENTS: Section 15000, "Mechanical General Provisions", applies to this section with the additions and modifications specified herein.
- 1.3 DESCRIPTION OF WORK: The work includes providing new and modifying existing medical gas and vacuum systems and related work. Provide each system complete and ready for operation. The system, including oxygen, medical air, vacuum, piping, equipment, materials, installation, workmanship, examination, inspection, and testing, shall be in accordance with the provisions of the National Fire Protection Association, except as modified herein.
- 1.4 SUBMITTALS
- A. Comply with Section 15000, Mechanical General Provisions.
 - B. Manufacturer's Data:
 - 1. Pipe and Fittings
 - 2. Valves
 - 3. Specialties
 - 4. Outlets
 - 5. Vacuum Pump

- 6. Storage Cabinets for Medical Gas and Oxygen Bottles
 - 7. Recessed Valve Boxes
 - 8. Alarm Panel
 - C. Certificates of Conformance:
 - 1. Test Instruments
 - 2. Medical Gas Systems Testing Agency
 - 3. Welder and Brazers Qualifications and Procedures
 - D. Medical Testing Agency Reports:
 - 1. Cross Connection Tests
 - 2. Alarm, Switchovers, Pressure Switch, and Equipment
 - 3. Final Purging and Testing
 - 4. System contaminate Level Tests
 - 5. Holding Charges
 - E. Contractor Test Report:
 - 1. Positive Pressure Tests (Include leak tests)
 - 2. Vacuum Systems Tests
 - F. Operation and Maintenance Manuals:
 - 1. Medical Air Systems
 - G. Posted Operating Instructions:
 - 1. Piping Systems Diagrams
 - 2. Medical Air Systems
- 1.5 SAFETY
- A. Welding, Brazing, and soldering: ANSI Z49.1

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS: Manufacturers shall be as indicated or approved equals.

2.2 PIPE AND FITTINGS: Sized and made for pressures and other design conditions as indicated.

A. Oxygen, Medical Air, and Vacuum Systems

1. ASTM B88 or ASTM B280 ACR (air conditioning and refrigeration), seamless Type K or L hard-drawn copper tubing for above ground and inside buildings. Standard weight (Schedule 40) brass pipe per ASTM B43 may be used. Use ANSI B16.18 cast copper, ANSI B16.22 wrought copper, or brass fittings.

- B. Oxygen, medical air, pipe shall be provided from the manufacturer certified clean for oxygen service. Piping intended for vacuum service is exempt from this requirement only if the contractor can ensure it will not be inadvertently used in the medical gas distribution system.

2.3 VALVES: NFPA 99, sized and made for pressures and other design conditions as indicated. Valves used for oxygen, medical air, service shall be provided from the manufacturer certified clean for oxygen service. Valves intended for vacuum service are exempt from this requirement only if the contractor can ensure they will not be used in the medical gas distribution system.

- A. Ball Valves: NFPA 99 bronze or stainless steel body as applicable, double-seal ball valves with replaceable Buna-N, neoprene, or polytetrafluoroethylene (TFE) seat seals. Valves shall be suitable for at least 300 pounds per square inch gauge (psig), non-shock working pressure, designed especially for the service intended. Mount valves in the line between flanges or unions. Valves of same type shall be the product of one manufacturer, uniform in pattern and appearance, and labeled for the intended service.

- B. Diaphragm Valves (Oxygen): MSS SP-88, brass-bodied, packless, diaphragm type with regrindable or renewable seats and disks capable of being disassembled in line for servicing o-ring and seating surfaces. Valves shall be suitable for at least 300 psig, nonshock working pressure.

- C. Gate Valves: (Vacuum and Medical Air Systems): MSS SP 80, bronze solder ends; or MSS SP 81, stainless steel, welded ends. Valves of like kind shall be of one manufacturer.

2.4 SPECIALTIES

- A. Hangers and Supports: Steel adjustable type per MSS SP-58 and MSS SP-69. Provide hangers, supports, nuts, bolts, and washers with hot-dip galvanized finish after fabrication.

- B. Piping Isolators: Commercial metal clad hair felt type for isolating pipe from hangers.

- C. Medical gas and oxygen storage cabinets for bottled gas shall be provided. Design basis is as shown on drawings.

- D. Flexible Connectors: Manufactured expressly for operating conditions either (1) annularly and helically corrugated flexible, single ply, seamless or seam-welded tubing with one or more layers of stainless steel or bronze wire braid, or (2) reinforced TFE bellows or hose. Use manufacturer's recommended lengths and sizes for the intended service.

- E. Vacuum pump shall be provided. Design basis is as shown on drawings.
 - F. Sleeves: 1/4 inch clearance around pipes.
 - 1. In Concrete and Masonry: Galvanized steel pipe.
 - 2. Partitions, Floors and Roofs, other than Concrete or masonry: 26-gauge galvanized sheet steel
 - G. Brazing Alloy: AWS A5.8, BCuP Series. Brazing filler metal shall be cadmium free.
 - H. Soldering Alloys: ASTM B 32, alloy Grade Sb5 or equivalent.
 - I. Welding Filler Metal: AWS A5.28 and compatible with the materials.
 - J. Piping Identification: Pressure sensitive adhesive tape and decals. Colors and labels shall conform with CGA Pamphlet C-9.
 - K. Nitrogen: For cleaning, purging, and testing use oil-free dry nitrogen as specified in paragraph entitled, "Test Gases".
- 2.5 OUTLETS: Sized and made for pressures and other design conditions as indicated.
- A. Quick-Connect Medical Gas Wall Outlet
 - 1. The quick-connect Medical Gas wall/ceiling outlets shall be gas specific for the services indicated and accept only corresponding quick-connect adapters. The outlets shall be UL listed, CSA certified, and be fully compliant with the latest edition of NFPA 99. All outlets shall be 100% tested for flow, leaks and connector attachment. The outlets shall be cleaned for oxygen service prior to shipping. The outlets shall be made in the U.S.A. A die cast, light gray, epoxy powder coated trim plate shall be provided to trim each wall/ceiling outlet and to fill the space between adjacent outlets. The trim plate shall allow latch valves to be individually removed for servicing.
 - 2. Outlet Design: A complete medical gas outlet shall consist of a gas-specific rough-in assembly for installation before the wall is finished and a matching gas-specific latch-valve assembly and cover plate for installation after the wall is finished.
 - 3. Rough-in Assembly: The rough-in assembly shall be of modular design and include a gas-specific 16-gauge steel mounting plate designed to permit on-site ganging of multiple outlets, in any order, on 5" centerline spacing. A machined brass outlet block shall be permanently attached to the mounting bracket to permit the 1/2" OD (3/8" nominal), type K copper inlet tube to swivel 360° for attachment to the piping system. Gas service identification shall be affixed to the inlet tube and the face of the mounting plate. A secondary valve shall be installed in the outlet block of the rough-in assembly for both pressure testing and preventing gas flow (except vacuum and WAGD) when the latch-valve assembly

is removed for service. A 3/8" high metal flange around the outlet opening shall provide a plaster barrier. A temporary cover shall be provided to keep debris out of the outlet during installation. The rough-in assembly shall contain a double seal to prevent gas leakage between the rough-in and latch-valve assemblies after the wall is finished. A single o-ring seal shall not be acceptable.

4. Latch Valve Assembly: The latch-valve assembly shall include a single compression seal primary valve, be gas specific for the labeled service, and accept only corresponding geometrically shaped hose and apparatus adapters. The latch-valve assembly shall be indexed to the corresponding rough-in assembly to avoid accidental cross-connection and shall telescope up to 3/4" to allow for variation in finished wall thickness from 1/2" up to 1-1/4". A metal cover plate insert with permanent, color-coded marking of service identification shall be included as part of the latch-valve assembly. A pushbutton release mechanism, for disconnecting apparatus, shall be accessible from the top, bottom and side of the outlet.
5. Outlets shall be as manufactured by Puritan Bennett or approved equal.

2.6 ZONE VALVE BOXES

- A. Zone Valve and Box Assembly: Valves shall be full port, double seal, ball-type with three piece bronze/brass body and a chrome-plated brass ball. Valves shall be designed for a maximum working pressure of 600 psig WOG or vacuum service to 29" Hg. Valve seals shall be glass-reinforced Teflon materials. All valve materials shall be compatible with USP oxygen, nitrous oxide, medical air, carbon dioxide, helium, nitrogen and mixtures thereof. A 1/4 turn of the handle shall be required to operate the valve from OPEN to CLOSED position. The valve shall be securely attached to the box and provided with type K copper tube extensions for making connection to system piping outside the box. All valves shall be serviceable in the line, supplied clean and prepared for oxygen service. All zone valve assemblies shall include a 1/8" NPT port with pipe plug as a provision for connection of a gauge. The gauge port shall be located on the terminal outlet side of the valve to register pipeline pressure or vacuum. The gauge shall be visible through the door of the zone valve box. The zone valve and box assembly shall meet all requirements of NFPA 99 and CAN/CSA-Z305.1.
- B. Zone Valve Box Design: The zone valve box shall be constructed of 18-gauge steel with white epoxy finish and provided with two galvanized steel brackets that anchors the box to the wall. Anchor brackets shall be designed to permit box assemblies to be ganged together in a vertical stack. Triple valve box assemblies require a rough wall opening of sufficient size to accommodate a nominal 11-7/8" wide x 15-1/2" high x 3-7/8" deep box. The zone valve box assembly shall have a sliding, opaque door with pull ring and clear gauge window. The door shall be capable of sliding to the right or left to facilitate installation requirements. In an emergency, the door shall SNAP-OUT by pulling the pull ring forward without exposing sharp edges. The zone valve box shall be provided with an anodized aluminum trim capable of adjusting to variations in wall thickness up to 1" below flush. The zone valve box assembly shall be supplied with color-coded gas identification labels. The assembly door shall have a label that reads:

- CAUTION -
MEDICAL GAS SHUT-OFF VALVES
CLOSE ONLY IN EMERGENCY

2.7 ALARMS

- A. Medical Electronic Gas Alarm: The alarm panel shall provide master and area alarm signals, as required by the latest edition of NFPA 99 and CSA Standard Z 305.1. The alarm shall be UL listed and CSA Certified. The alarm panel shall meet the FDA Electromagnetic Compatibility Standard for Medical Devices MDS-201-0004 to reduce the possibility of magnetic radiation interference with other equipment. All field wiring and signals shall be self-monitoring and on a closed circuit. Fault signals shall be on an open circuit. The alarm system shall have a modular design allowing modules to be arranged vertically, horizontally, or a combination of both. The finish trim shall consist of a light gray epoxy powder-coated trim plate with an easily removed plastic cover plate.
- B. The Power Supply Module: The power supply module shall convert 120 or 240 VAC to low voltage DC. This module shall contain a fuse to protect the system from power surges. An amber POWER ON indicator shall illuminate when the alarm panel is powered. The power supply module shall provide an audible signal that is activated by a digital display module or multi-signal alarm module. The audible signal shall have a minimum sound pressure level of 90 dBA measured at a distance of 3 ft (1m).
- C. The Digital Module: The digital display module shall be used as either a master alarm or area alarm. The digital liquid crystal display (LCD) continuously indicates the pressure or vacuum in the piping system being monitored. The display shall be programmable to read psig, in Hg, or kPa in increments of 1 psig, 1 in Hg, or 7 kPa respectively. The digital display module shall provide an audible and visual signal when a fault condition occurs. The digital display module shall be provided with a button to silence the audible alarm. The visual signal shall automatically cancel when the fault is corrected. The visual signals for system pressure or vacuum shall read NORMAL (green LED), LOW (red LED), and HIGH (red LED). Signal limits shall be factory set as required by code and field programmable without the use of tools. Each digital display module shall provide three additional signals with the ability to field label the system function being monitored (i.e., reserve, lag, dew point, etc.). The first signal shall be a yellow LED, the second a red LED and the third a flashing red LED. The green system status NORMAL indicator shall turn off whenever a fault signal is received or flashes upon receipt of an advisory signal (i.e., secondary supply). The alarm shall be of the closed-circuit self-monitoring type, signaling abnormal conditions when the switch contacts are in the open position. The digital display module shall incorporate a self-test function to test LCD, LEDs, audible alarm, and to view the alarm set points. Each digital display module shall be equipped with a general fault relay output (30 VAC/VDC 2A max). Pressure or vacuum signals on one digital display module shall be capable of being monitored by additional digital display modules.
- D. The Sensor Module: The sensor module shall contain a transducer capable of providing calibrated signals to the digital display module. Sensor modules shall be gas specific and be capable mounting directly in the medical gas pipeline or in standard wall construction. Sensor modules may be installed in the ceiling. A sensor module is required for each digital display module. Pipeline connections shall be 3/8" nominal (1/2" OD) type K

copper tube. Connectors shall be provided for attaching field wiring. Sensors shall be removable for periodic testing as required by code without the need to change medical gas pipeline pressures or vacuum.

- E. Multi-Signal Alarm Module: The multi-signal alarm module shall be capable of monitoring up to six dry-contact signals. Each signal shall illuminate a green LED to indicate that conditions are normal. When a fault occurs, the green LED shall turn off, the red LED shall illuminate, and the audible alarm shall sound. The red LED can be field programmed to illuminate as solid red or flashing red. Each multi-signal alarm module shall be provided with a button to silence the audible alarm. The visual alarm shall remain illuminated until the fault condition has been corrected. Unused signals shall have the ability to be deactivated in the field. Field programming can be accomplished without the use of tools. The alarm shall be of the closed-circuit self-monitoring type, signaling abnormal conditions when the switch contacts are in the open position. The multi-signal alarm module shall incorporate a self-test function to test LEDs, audible alarm, and signal display mode. Each digital display module shall be equipped with a general fault relay output (30 VAC/VDC 2A max).

PART 3 - EXECUTION

3.1 INSTALLATION: NFPA 99, and CGA P-2.1.

3.2 PIPING

- A. Piping and components shall be cleaned for oxygen service prior to arriving at the job site in accordance with NFPA 99. All material shall remain plugged, capped or otherwise sealed until final assembly. Material shall be visually examined internally for contamination immediately before final assembly. Material which has become contaminated and is no longer suitable for oxygen service shall not be installed. On-site cleaning of the interior surfaces of tubes, valves, fittings or other components shall be limited to recleaning surfaces in the immediate vicinity of joints that have become contaminated prior to brazing. For this cleaning, wash surfaces in a clean, hot water/alkaline solution of sodium carbonate or trisodium phosphate (1 lb. to 3 gal. of potable water). The surfaces shall be thoroughly scrubbed and rinsed with clean, hot, potable water.
- B. Piping Installation: Exercise care with cutting, brushing, and reaming tools and equipment to prevent oil, grease, and dirt from entering pipe and components. Rewash all contaminated pipe and components. Cut pipe square and accurately to measurements and work into place without springing or forcing. Follow the general arrangement indicated. Do not bury embed or conceal piping except as indicated. Do not install piping near high voltage lines. At the end of each work shift shut off valves, and cap or plug open ends. As work progresses valve off each section. Prevent moisture or dirt from entering piping.
- C. Exposed Oxygen Piping: Install in wall mounted sheet steel raceways and junction boxes.
- D. Threaded Joints: Coat male threads of fittings used in shutoff valves with teflon tape before assembly.

- E. Brazing and soldering: Personnel qualification procedures shall conform with AWS B2.2. Metal preparation and joining procedures shall conform with AWS B2.2. Metal preparation and joining procedures shall conform with the CDA 412/6 and NFPA 99. Do not use flux, except those requiring the joining of copper and brass or other dissimilar metals. Completely clean off the excess after brazing and soldering. Apply brazing and soldering alloys in accordance with Table I.

TABLE I

BRAZING AND SOLDERING ALLOY APPLICATIONS

<u>System</u>	<u>Pipe Sizes</u>	
	2-Inch and Smaller	2-1/2 Inch and Larger
Oxygen	BCuP Series	BCuP Series
Vacuum	Tin-Antimony	BCuP Series
Medical Air	BCuP Series	

- F. Welding: In accordance with AWS B2.1
- G. Purging and Blowing Clear: During brazing, soldering, or welding operation, continuously purge with oil free nitrogen. As each section is completed, blow clear of dirt and contamination with oil-free dry nitrogen in accordance with NFPA-99. Cap or plug open ends, if they are left unattended for any length of time.
- H. Grounding: Ground metal piping systems in accordance with Division 16.
- I. Pitch: Pitch piping in the direction of flow. Do not install any system as to provide a trap.
- J. Changes in size: Effect changes in size with reducing fittings. The use of bushings shall not be permitted.
- K. Supports: Rigidly support all valves and other equipment where installation or operation might strain the pipe.
- L. Pipe sleeves: Provide pipe sleeves where pipes and tubing pass through walls, and partitions. Secure sleeves in proper position and location before and during construction. Drive sleeves of sufficient length to pass through entire thickness of walls, or partitions, and be flush at both ends. Firmly pack the space between the pipe or tubing and the sleeve with oakum and caulk on both ends of the sleeve with plastic cement.
- M. Identification of Piping: Identify all piping with tape and decals conforming with CGA Pamphlet C-9 in lieu of stencils and paint. Provide copies of the piping identification code and piping layout schematic framed under glass and install where directed.

- N. Cleaning, Purging and Blowing Clear: As each section of piping is completed, purge, clean, and blow clear of contaminants in accordance with NFPA 99 using oil-free dry nitrogen. Do not use other gas, neutral, or liquid. Cap or plug open ends if they are left unattended for any length of time.
- 3.3 VALVES: Disassemble all solder socket end valves before brazing, soldering or welding to prevent damage to seats and seals. Except where indicated or in flush wall mounted cabinets, install valves with the stem vertical and with the valves accessible for operation and maintenance. Install strainers on the inlet side of all pressure reducing valves. Provide main gas valves (pressure reducing or flow control) with by-passes and isolation valves to permit main valve maintenance and permit flow to the patient care areas without interruption of gas.
- 3.4 HANGERS AND SUPPORTS: Design, selection, fabrication, and installation of piping hangers and supports shall conform with MSS SP-58 and MSS S-69 except that spacing of the hangers and supports shall be in accordance with Table II. When pipe is installed on trapeze hangers, the hanger spacing shall conform to the requirements of lowest strength pipe.

TABLE II

MAXIMUM SPAN FOR PIPE HANGERS (feet)

Copper tube, Type K (Cu-K) and Type L (CU-L), and brass

<u>Pipe Size</u> (inches)	<u>Cu-k and Brass</u>	<u>Cu-L</u>
1/2	3'-9"	3'-6"
3/4	4'-3"	4'-3"
1	5'-0"	4'-9"

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified independent testing and inspecting agency to perform the following field tests and inspections and prepare test reports.
- C. Perform the following field tests and inspections and prepare test reports:
1. Inspect, test, and certify completed medical gas systems according to requirements in NFPA 99. Inspect, test, and certify each medical gas piping system, including specialties, service connections, alarm system, safety devices, and source equipment.
 2. Provide oil-free dry nitrogen, medical gases, materials, and equipment required for testing.

3. Level 1 Pressure Medical Gas Testing: Use oil-free dry nitrogen, unless otherwise indicated, and perform procedures and tests as indicated in NFPA 99 performance and testing paragraphs for piped gas systems. Include the following:
 - a. Performance Testing:
 - (1) Blow Down: Clear piping before connecting service connections or outlets.
 - (2) Initial Pressure Tests: Subject each piping section to test pressure of 1.5 times system working pressure, but not less than 150 psig (1035 kPa), before attaching system components, after installing station outlets with test caps (if supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water. Repair leaks with new materials and retest systems.
 - (3) Cross-Connection Tests: Determine that no cross connections of piping systems exist. Disconnect all systems except system to be checked. Pressurize system to 50 psig (345 kPa). Verify that gas flow from service connections and outlets is only from system being checked. Repeat for each system. Verify correct labeling.
 - (4) Purge Tests: Perform heavy intermittent purging of piping and full-flow purging of service connections.
 - (5) Standing-Pressure Tests: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at 20 percent above normal line pressure. Verify that pressure differences comply with required calibration. Repair leaks with new materials and retest systems.
 - b. System Verification:
 - (1) Cross-Connection Tests: Repeat cross-connection test above or perform alternate tests with each gas at different pressure.
 - (2) Flow Tests: Perform flow test at each outlet.
 - (3) Valve Tests: Verify proper valve operation.
 - (4) Alarm Tests: Operate systems and verify proper warning indication of each medical gas piping system function.
 - (5) Piping Purity Tests: Test for dew point and hydrocarbons as compared to source gas.

- (6) Final Tie-End Tests: Verify that above tests have been successfully performed.
 - (7) Operational Pressure Tests: Use designated system gases and test for pressure and flow.
 - (8) Medical Gas Concentration Tests: Test each gas for required concentration.
 - (9) Labeling: Verify correct labeling.
- 4. Level 1 Vacuum System Testing: Use oil-free dry nitrogen, unless otherwise indicated, and perform procedures and tests as indicated in NFPA 99 performance and testing paragraphs for piped vacuum systems. Include the following:
 - a. Blow Down: Clear piping before connecting service connections or inlets.
 - b. Initial Pressure Tests: Subject each piping section to test pressure not less than 150 psig (1035 kPa) before attaching system components, after installing station outlets with test caps (if supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water. Repair leaks with new materials and retest systems.
 - c. Initial Cross-Connection Tests: Determine that no cross connections of piping systems exist. Disconnect all systems except system to be checked. Pressurize system to 50 psig (345 kPa). Verify that gas flow from service connections and outlets is only from system being checked. Repeat for each system. Verify correct labeling.
 - d. Standing-Pressure Tests: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at not less than 60 psig (415 kPa).
 - e. Final Cross-Connection Tests: Repeat cross-connection test above or perform alternate tests with each system at different pressure.
 - f. Vacuum Tests: Verify functional operation of components.
 - g. Valve Tests: Verify proper valve operation.
 - h. Alarm Tests: Operate systems and verify proper warning indication of each medical gas piping system function.
 - i. Labeling: Verify correct labeling.
- D. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - 1. Inspections performed.

2. Procedures, materials, and gases used.
3. Test methods used.
4. Results of tests.

END OF MEDICAL GAS SYSTEM

SECTION 15480

EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS

PART 1 - GENERAL

- 1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 422	(1963; R 1990) Particle-Size Analysis of Soils
ASTM D 1556	(1990) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))
ASTM D 2487	(1993) Classification of Soils for Engineering Purposes (Unified Soil Classification System)

1.2 DEFINITIONS

- A. Degree of Compaction: Degree of compaction shall be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 15000, Mechanical General Provisions.

SD-09 Reports: Field Density Tests. Testing of Backfill Materials.

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Materials: Satisfactory materials shall consist of any material classified by ASTM D 2487 as GW, GP, and SW.
- B. Unsatisfactory Materials: Unsatisfactory materials shall be materials that do not comply with the requirements for satisfactory materials. Unsatisfactory materials include but are not limited to those materials containing roots and other organic matter, trash, debris, frozen materials and stones larger than 3 inches, and materials classified in ASTM D 2487, as PT, OH, and OL. Unsatisfactory materials also include man-made fills, refuse, or backfills from previous construction.
- C. Cohesionless and Cohesive Materials: Cohesionless materials shall include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM

will be identified as cohesionless only when the fines are nonplastic.

- D. Rock: Rock shall consist of boulders measuring 1/2 cubic yard or more and materials that cannot be removed without systematic drilling and blasting such as rock material in ledges, bedded deposits, unstratified masses and conglomerate deposits, and below ground concrete or masonry structures, exceeding 1/2 cubic yard in volume, except that pavements will not be considered as rock.
- E. Unyielding Material: Unyielding material shall consist of rock and gravelly soils with stones greater than 3 inches in any dimension or as defined by the pipe manufacturer, whichever is smaller.
- F. Unstable Material: Unstable material shall consist of materials too wet to properly support the utility pipe, conduit, or appurtenant structure.
- G. Select Granular Material: Select granular material shall consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles, and shall contain not more than 10 percent by weight of material passing a No. 200 mesh sieve and no less than 95 percent by weight passing the 1 inch sieve. The maximum allowable aggregate size shall be 3 inches, or the maximum size recommended by the pipe manufacturer, whichever is smaller.
- H. Initial Backfill Material: Initial backfill shall consist of select granular material or satisfactory materials free from rocks 3 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, the initial backfill material shall be free of stones larger than 1 inch in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

PART 3 - EXECUTION

- 3.1 EXCAVATION: Excavation shall be performed to the lines and grades indicated. Rock excavation shall include removal and disposition of material defined as rock in paragraph MATERIALS. Earth excavation shall include removal and disposal of material not classified as rock excavation. During excavation, material satisfactory for backfilling shall be stockpiled in an orderly manner at a distance from the banks of the trench equal to $\square$ the depth of the excavation, but in no instance closer than 2 feet. Excavated material not required or not satisfactory for backfill shall be removed from the site. Grading shall be done as may be necessary to prevent surface water from flowing into the excavation, and any water accumulating therein shall be removed to maintain the stability of the bottom and sides of the excavation. Unauthorized overexcavation shall be backfilled in accordance with paragraph BACKFILLING AND COMPACTION at no additional cost to the City of Norfolk.
- A. Trench Excavation: The trench shall be excavated as recommended by the manufacturer of the pipe to be installed. Trench walls below the top of the pipe shall be sloped, or made vertical, and of such width as recommended in the manufacturer's installation manual. Where no manufacturer's installation manual is available, trench walls shall be made vertical. Trench walls more than 30 feet high shall be shored, cut back to a stable slope, or provided with equivalent means of protection for employees who may be exposed to moving ground or cave in. Vertical trench walls more than 5 feet high shall be shored. Trench walls which are cut back shall be excavated to at least the angle of repose of the soil. Special attention shall be given to slopes which may be adversely affected by weather or moisture content. The trench width below the top of pipe shall not

exceed 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter and shall not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, redesign, stronger pipe, or special installation procedures shall be utilized by the Contractor. The cost of redesign, stronger pipe, or special installation procedures shall be borne by the Contractor without any additional cost to the City of Norfolk.

1. Bottom Preparation: The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Bell holes shall be excavated to the necessary size at each joint or coupling to eliminate point bearing. Stones of 3 inches or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.
2. Removal of Unyielding Material: Where unyielding material is encountered in the bottom of the trench, such material shall be removed 4 inches below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.
3. Removal of Unstable Material: Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed and replaced to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the fault or neglect of the Contractor in his performance of the work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the City of Norfolk.
4. Excavation for Appurtenances: Excavation for manholes, catch-basins, inlets, or similar structures shall be sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members. Rock shall be cleaned of loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified above. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.
5. Stockpiles: Stockpiles of satisfactory, unsatisfactory, and wasted materials shall be placed and graded as specified. Stockpiles shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared, grubbed, and sealed by rubber-tired equipment, excavated satisfactory and unsatisfactory materials shall be separately stockpiled. Stockpiles of satisfactory materials shall be protected from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, such material shall be removed and replaced with satisfactory material from approved sources at no additional cost to the City of Norfolk. Locations of stockpiles of satisfactory materials shall be subject to prior approval of the Activity.

- 3.2 BACKFILLING AND COMPACTION: Backfill material shall consist of satisfactory material, select granular material, or initial backfill material as required. Backfill shall be placed in layers not

exceeding 6 inches loose thickness for compaction by hand operated machine compactors, and 8 inches loose thickness for other than hand operated machines, unless otherwise specified. Each layer shall be compacted to at least 95 percent maximum density for cohesionless soils and 90 percent maximum density for cohesive soils, unless otherwise specified.

- A. Trench Backfill: Trenches shall be backfilled to the grade shown. The trench shall not be backfilled until all specified tests are performed.
 - 1. Replacement of Unyielding Material: Unyielding material removed from the bottom of the trench shall be replaced with select granular material or initial backfill material.
 - 2. Replacement of Unstable Material: Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 6 inches loose thickness.
 - 3. Bedding and Initial Backfill: Bedding shall be of the type and thickness shown. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe.
 - 4. Final Backfill: The remainder of the trench, shall be filled with satisfactory material. Backfill material shall be placed and compacted as follows:
 - a. Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas: Backfill shall be deposited in layers of a maximum of 12 inch loose thickness, and compacted to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. This requirement shall also apply to all other areas not specifically designated above.
- B. Backfill for Appurtenances: After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure, backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.3 TESTING: Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the City of Norfolk.

- A. Testing Facilities: Tests shall be performed by an approved commercial testing laboratory or may be tested by facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved by the Activity. The first inspection shall be at the expense of the City of Norfolk. Cost incurred for any subsequent inspection required because of failure of the first inspection will be charged to the Contractor.
- B. Testing of Backfill Materials: Characteristics of backfill materials shall be determined in accordance with particle size analysis of soils ASTM D 422 and moisture-density relations of soils ASTM D 1557. A minimum of one particle size analysis and one moisture-density relation test shall be performed on each different type of material used

for bedding and backfill.

- C. Field Density Tests: Tests shall be performed in sufficient numbers to ensure that the specified density is being obtained. A minimum of one field density test per lift of backfill for every 30 feet of installation shall be performed. One moisture density relationship shall be determined for every 1500 cubic yards of material used. Field in-place density shall be determined in accordance with ASTM D 1556. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job, on each different type of material encountered. Copies of calibration curves, results of calibration tests, and field and laboratory density tests shall be furnished to the Activity. Trenches improperly compacted shall be reopened to the depth directed, then refilled and compacted to the density specified at no additional cost to the City of Norfolk.

END OF EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS

SECTION 15612
GAS DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the test by the basic designation only.

A. Federal Specifications (Fed. Spec.):

L-C-530B(1)	Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy
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L-T-1512A	Tape, Pressure Sensitive Adhesive, Pipe Wrapping
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WW-V-35B(1)	Valve, Ball
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B. Military Specifications (Mil. Spec.):

MIL-C-18480B	Coating Compound, Bituminous, Solvent, Coal Tar Base
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MIL-T-27730A	Tape, Antiseize, Tetrafluoroethylene, with Dispenser
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C. American National Standards Institute (ANSI) Publications:

A21.14-79	Ductile-Iron Fittings, 3-inch through 24-inch for Gas
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A21.52-82	Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand-Lined Molds for Gas
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B16.1-75	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
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B16.5-81	Steel Pipe Flanges, Flanged Valves and Fittings Including Ratings for Class 150, 300, 400, 600, 900, 1500, and 2500
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B16.9-78	Factory-Made Wrought Steel Buttwelding Fittings
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B16.11-80	Forged Steel Fittings, Socket-Welding and Threaded
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B31.8-82	Gas Transmission and Distribution Piping Systems
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D. American Petroleum Institute (API) Publications:

5L-83	Specification for Line Pipe
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6D-82	Specification for Pipeline Valves
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1104-83	Standard for Welding Pipe Lines and Related Facilities
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- E. American Society of Mechanical Engineers (ASME) Publication:
- | | |
|-------------|--------------------------|
| PTC 25.3-76 | Safety and Relief Valves |
|-------------|--------------------------|
- F. American Society for Testing and Materials (ASTM) Publications:
- | | |
|--------------------|---|
| A 53-82 | Pipe, Steel, Black and Hot-Dipped Zinc-Coated Welded and Seamless Steel Pipe |
| A 135-79 | Electric-Resistance-Welded Steel Pipe |
| A 139-74 | Electric-Fusion (ARC)-Welded Steel Pipe (Sizes 4 inch and over) |
| D 1598-81 | Time-to-failure of Plastic Pipe under Constant Internal Pressure, Test Method for |
| D 1599-82 | Short-Time Rupture Strength of Plastic Pipe, Tubing, and Fittings, Method of Test for |
| D 2513-82 | Thermoplastic Gas Pressure Pipe, Tubing and Fittings |
| D 2517-81 | Reinforced Epoxy Resin Gas Pressure Pipe and Fittings |
| D 2774-72 (R 1978) | Underground Installation of Thermoplastic Pressure Piping |
| D 3839-79 | Underground Installation of Flexible Reinforced Thermosetting Resin Pipe and Reinforced Plastic Mortar Pipe |
- G. American Water Works Association (AWWA) Publications:
- | | |
|----------------|--|
| C111/A21.11-80 | Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings |
| C203-78 | Coal Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied |
| C600-82 | Installation of Ductile-Iron Water Mains and Their Appurtenances |
- H. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS-SP) Publication:
- | | |
|------------|-----------------------|
| SP 78-1977 | Cast Iron Plug Valves |
|------------|-----------------------|
- I. Steel Structures Painting Council (SSPC) Painting Manual, Vol 2 (1982):
- | | |
|---------------|--|
| SSPC-SP3 | Power Tool Cleaning |
| SSPC-Paint 11 | Red Iron Oxide, Zinc Chromate, Raw Linseed Oil, and Alkyd Primer |

1.2 GENERAL REQUIREMENTS: Section 15000, "Mechanical General Requirements", applies to this section except where otherwise specified.

- A. Gas Distribution System: The system includes piping and appurtenances from point of connection with existing system as indicated to a point approximately 5 feet from the building(s).
- B. Gas Distribution Mains: Piping for gas distribution mains shall be black steel, thermoplastic (Polyethylene - PE, as specified. Provide shut off valves where indicated.
- C. Gas Service Lines: Gas service lines shall include the pipelines from the gas distribution mains to the building service at a point approximately 5 feet from the building. Gas service lines shall be black steel pipe, or polyethylene (PE) as specified. Terminate each gas service pipeline with a fitting suitable for accepting black steel pipe of the same nominal diameter.

1.3 SUBMITTALS

- A. Manufacturer's Data:
 - 1. Pipe and Pipe Coatings
 - 2. Fittings
 - 3. Joints and Couplings
 - 4. Valves
 - 5. Valve Boxes
 - 6. Reinforcing Sleeves
 - 7. Tapping Saddles
- B. Test Reports: Certified copies of piping pressure tests.
- C. Certificates of Compliance:
 - 1. Welders procedures and qualifications (metal and PE)
 - 2. Pipe coating materials and application procedure

1.4 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

- A. Delivery and Storage: Inspect materials delivered to the site for damage, and store with a minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

- B. Handling: Handle pipe, fittings, valves, and other accessories in such manner as to insure delivery to the trench in sound, undamaged condition. Take special care not to injure coatings on pipe and fittings. If coatings are damaged, repairs satisfactory to the Contracting Officer shall be made at no extra cost to the Government. Plastic piping that is not to be installed immediately shall not be left in the sunlight.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: Conform to *ANSI B31.8 to the extent specified herein, and to the respective specifications and the other requirements specified below.

2.2 PIPING MATERIALS FOR GAS DISTRIBUTION MAINS: Piping shall be black steel, PE, as specified below.

A. Steel Pipe and Fittings: API 5L, Grade A, B, or X42, *ASTM A 53, Grade A or B, *ASTM A 135, or *ASTM A 139, Grade A or B. Coat pipe and fittings for underground lines as specified in paragraph, "Shop-Applied Coatings for Buried Steel Pipe and Fittings". Do not coat pipe and fittings for above ground lines. Ends of pipe and fittings shall be suitable for the joints and jointing materials used. Buttweld fittings shall be wrought steel, *ANSI B16.9. Socket weld and threaded fittings shall be forged steel, ANSI B16.11.

1. Wall Thickness for Pipe and Fittings: The minimum wall thickness for steel pipe and fittings, based upon steel having a minimum specified yield strength of 30,000 psi, shall be equivalent to Schedule 40.

2. Joints and Jointing Materials:

a. General: Pipe and fittings shall have welded joints [except as otherwise indicated or specified]. Use threaded joints where indicated.

B. Thermoplastic (Polyethylene - PE) Pipe and Fittings:

1. Pipe and Fittings: PE pipe and heat fusion fittings shall conform to *ASTM D 2513, Grade P33 or P34, SDR 13.5. Ends of the pipe and fittings shall be suitable for the joints specified.

2. Joints and Jointing Materials: PE pipe and fittings shall have heat fusion joints, except that approved mechanical crimp-type fittings conforming to paragraph, "Mechanical Crimp-Type Fittings for PE Pipe", may be used for 3/8-inch OD to 2-inch IPS sizes. PE pipe and fitting materials for heat fusion shall be compatible to ensure uniform melting and a proper bond.

C. Mechanical Crimp-Type Fittings for PE Pipe: Axial crimp-type mechanical fittings for 3/8-inch OD thru 2-inch IPS PE tubing and pipe shall be made specifically for use in gas piping systems. Fittings shall have plastic bodies with molded-in-place internal metal sleeves to fit the inside diameter of the pipe and shall be assembled on the pipe with nonremovable stainless steel axial crimping sleeves furnished as part of the fitting. Tensile strength of the fittings and fitting pull-out strength shall exceed that of the pipe on which installed. Fittings shall have passed sustained pressure tests at 200 psig and burst pressure tests at 400 psig conforming to *ASTM Test Methods D 1598 and D 1599 respectively. Test data certifying that fittings of the same type, material, and pressure rating as those being proposed have passed all the above tests, shall be submitted for approval.

2.3 PIPING MATERIALS FOR GAS SERVICE LINES

- A. Steel Pipe, Fittings, Joints and Jointing Materials: Shall be as specified for steel pipe for gas distribution mains. Threaded fittings shall be black malleable iron or steel. Do not install close nipples and unions underground.
- B. PE Pipe and Fittings: PE pipe and heat fusion fittings shall conform to *ASTM D 2513. Minimum wall thickness shall be as specified in *ASTM D 2513. PE pipe and fittings shall have joints as specified for gas distribution main piping.

2.4 GAS MAIN VALVES AND ACCESSORIES

- A. Shut-Off Valves for Gas Distribution Main and Regulator Station Piping: All manually operated shut-off valves shall have a minimum pressure rating of 150 psig.

- 1. Ball Valves: AGA or CSA approved 150 psi to 300 psi. Valves shall be full bore type. Minimum bore size for full bore valves shall be 95 percent of the internal cross sectional area of pipe of the same nominal diameter.

Nominal Valve Size (Inches)	Torque (foot-pounds)
[3/4] [1] [1-1/2] [2]	[25]

- B. Gas Main Regulator Station: Shall include regulator valve, relief valve, strainer, regulator by-pass piping, and shut-off valves as indicated. All regulator station piping and all piping from the buried gas lines to the regulator station shall be steel piping as specified for gas distribution main piping. All regulator station piping, fittings and valves shall be welded joint [except where [flanged] [and] [threaded] joints are indicated]. All pipe and equipment supports shall be of non-combustible material. Regulator station shall be located [in an underground vault] [aboveground] as indicated.

- 1. Regulator Valve: Shall have steel or ductile-iron body, and [flanged] [threaded] ends. The regulator valve shall conform to the indicated requirements, as to size, capacity, and reduction of indicated pressure. Provide overpressure protection to prevent gas pressure from exceeding the indicated value in accordance with *ANSI B31.8.
 - 2. Pressure relief valve shall be designed to prevent gas pressure from exceeding the indicated value, shall have sufficient capacity to prevent overpressuring the system, and shall be adjusted to ensure that [a pressure increase shall not cause the unsafe operation of any connected and properly adjusted gas utilization equipment in a low-pressure distribution system] [the maximum pressure shall not exceed the maximum allowable operating pressure plus 6 psig in a high pressure system]. Each pressure relief valve shall meet the performance standards set forth in *ASME PTC 25.3, and shall be steel or cast iron.
 - 3. Strainer shall be designed to remove particulate matter from the gas stream and shall have a steel or cast iron housing with a removable stainless steel strainer basket with a mesh sized to remove all particles that would interfere with regulator valve operation.

- 4. Shut-off valves shall be ball type.
 - C. Valve Boxes: Provide each valve on gas piping with a plastic or metal valve box of a size suitable for the valve. The valve box shall have a cover with the work "Gas" on it. The valve boxes shall be provided with covers.
 - D. Drips: Provide drip legs at each point of connection to equipment or lab valves.
- 2.5 GAS SERVICE LINE VALVES AND ACCESSORIES
- A. Shut-Off Valves: Shut-off valves for gas service line piping shall be ball valves, and shall be provided where indicated with a pressure rating of 150 psig and shall have threaded ends.
 - B. Emergency Shut Valves: Provide readily accessible emergency valves behind each individual work station or wall above centers.
- 2.6 CASING PIPE: Schedule 40 60 PVC. Provide PVC casing on all pipe below floors and in walls, sealed at outlets and vented to the atmosphere.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPELINES

- A. General Requirements:
 - 1. Pipe Laying and Jointing: Pipe, fittings, valves and accessories will be carefully inspected by the Contracting Officer or his authorized representative before and after installation and those found defective will be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, clean pipe, fittings, valves, and accessories and maintain in a clean condition. Cut pipe accurately to measurements established at the site and work into place without springing or forcing. Replace any pipe or fitting that does not allow sufficient space for proper installation of jointing material with one of proper dimensions. Grade the pipe in straight lines, taking care to avoid the formation of any dips or low points. Support pipe at its proper elevation and grade, taking care to secure firm and uniform support. wood support blocking will not be permitted. The full length of each section of pipe and all fittings shall rest solidly on the pipe bed, with recesses excavated to accommodate joints and couplings. Provide anchors and supports where indicated. Close open ends of pipe at the end of each day's work temporarily with plastic end closures.
- B. Special Requirements for Installation of Steel Gas Main Piping:
 - 1. General: Install pipelines as specified herein and in accordance with the applicable requirements of *ANSI B31.8.
 - 2. Earthwork: Employ hand excavation within 5 feet of other underground structures. Special care shall be taken during earthwork operations not to damage the pipe.

3. Joints: Threaded joints shall have tapered threads, evenly cut, and shall be made with Underwriter's Laboratories approved graphite compound for gas service or with polytetrafluoroethylene tape conforming to *Mil. Spec. MIL-T-27730, applied to the male threads only. After cutting and before threading, ream pipe and remove burrs. Caulking of threaded joints to stop or prevent leaks will not be permitted.
- C. Special Requirements for Installation of PE Gas Main Piping:
1. General: Install pipelines as specified herein and in accordance with the applicable requirements of *ANSI B31.8 and *ASTM D 2774 *ASTM D 3839. Maintain a minimum of 12 inches clearance between PE pipe and heating system piping.
 2. Joints: Make joints for PE pipe for plastic pipe or tubing and fittings in accordance with *ANSI B31.8 and the recommendations of the manufacturer of the pipe or tubing and fittings for the material being used.
- D. Special Requirements for Installation of Gas Service Piping:
1. General: Work shall include the connection to the building piping where the building piping has been installed. Where building piping has not been installed, terminate service lines with a temporary cap approximately five feet from the building line at a point directed by the Contracting Officer or his authorized representative. Installation shall be in accordance with the general requirements for installation of pipelines and with the applicable requirements of *ANSI B31.8. Installation of PE pipe or tubing shall further be in accordance with the applicable requirements of *ASTM D 2774.
 2. Service Connections: Make all service connections at the top of the main, whenever the depth of the main is sufficient to allow top connections. When service connections cannot be made at the top of the main, they shall be made on the side of the main as close to the top as possible. Service connections shall not be made lower than the horizontal midpoint of the gas main. All service connections shall be installed in accordance with the applicable requirements of *ANSI B31.8.
 3. Joints:
 - a. Steel Pipe: Make joints for steel service line piping as specified for steel distribution main piping.
 - b. PE Pipe or Tubing: Make joints for PE pipe or tubing and fittings in accordance with *ANSI B31.8 and the recommendations of the manufacturer of the pipe or tubing and fittings.

3.2 FIELD TESTS AND INSPECTIONS

- A. General: The Contractor shall obtain the services of the local gas distributing utility to provide a qualified gas pipeline inspector to perform inspections and witness all testing of the gas distribution system. The inspector shall provide a written report of his findings and recommendations at intervals as required to correct any deficiencies and after final

testing is complete do not coat, bury, cover or conceal joints and fittings until they have been inspected, tested and approved.

- B. Testing of Pipe Coatings: Check coated pipe for discontinuities in the coating with use of an electrical holiday detector at 10,000 volts prior to lowering into trench. Repair holidays in the pipe coating in accordance with paragraph titled "Application of Plastic Tape".
- C. Inspection and Testing of Welds: Inspect quality of welded joints visually on a sampling basis. Defective welds shall be repaired or removed from the line.
- D. Piping Strength and Tightness Tests: Test all gas distribution system piping for leaks with air at 100 psig after construction and before being placed in service. Disconnect piping under test from live gas piping systems. Where possible, test main and service pipe as a unit. Service line connections Pipe joints which are not included in the pressure test shall be given a leakage test at normal operating pressure after the piping system is placed in operation. Maintain a permanent written record of pressure test performed and furnish a copy to the Contracting Officer.
- E. Purge mains and service lines before placing in service in accordance with *ANSI B31.8, Section 841.275.

3.3 LABELING: Gas pipe shall be labeled every 10 ft and at every valve and at every branch.

3.4 FINAL CLEAN-UP: Upon completion of the work, remove and dispose of all excess spoil and leave the areas in a clean condition. Restore service line trenches as nearly as possible to the original appearance and condition.

END OF GAS DISTRIBUTION SYSTEM

SECTION 15671
DUCTLESS SPLIT SYSTEMS

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 WORK INCLUDED

- A. Ductless split systems (indoor unit and outdoor unit)

1.3 QUALITY ASSURANCE

- A. Conform to the following standards:
 - 1. UL
 - 2. ARI

1.4 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 15000, "MECHANICAL GENERAL PROVISIONS".
- B. Submit product data including certified performance data at specified design conditions; complete dimensional data on the indoor unit and outdoor unit; control and wiring diagrams, pipe connection sizes.
- C. Submit manufacturer's installation instructions.
- D. Manufacturer's Data:
 - 1. DSS
- E. Operation and Maintenance Manuals:
 - 1. DSS

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

- A. EMI - Enviromaster International
- B. Trane
- C. Mitsubishi

2.2 GENERAL

- A. System capacity shall be as scheduled on the drawings.
- B. System shall have a minimum 13 SEER.

2.3 OUTDOOR UNIT

A. UNIT CASING

- 1. Outdoor units will be designed for outdoor application and shall provide complete protection for all components and controls. Unit casing shall be capable of withstanding 500-hour salt spray test.
- 2. Casings will have removable panels to provide complete access to compressor, controls, condenser fan, motor and drive.
- 3. The unit will ship complete in one section as a factory assembly.
- 4. All exposed surfaces of the unit casing will be of galvanized steel, phosphatized for maximum paint adhesion and finished with an air-dry paint coating.

B. COMPRESSOR-MOTOR

- 1. Compressor shall be scroll or reciprocating of the hermetic type, direct driven 3600 RPM and designed for air-cooled operation. Lubrication shall be manufacturer's standard system.
- 2. Compressor shall have overcurrent and thermal protection.
- 3. Each compressor shall be equipped with a crankcase heater factory sized to control oil dilution during shutdown.
- 4. Provide 5 year warranty on compressor.

C. CONDENSING SECTION

- 1. Condenser coil will be of seamless copper tubing mechanically bonded to configured aluminum fins.
- 2. A liquid accumulator and subcooling circuit will be included as a standard part of the condensing section.
- 3. Unit will be equipped with a backseating liquid line service access valve.
- 4. Condenser coils should be factory tested at 450 psig air pressure and vacuum dehydrated.
- 5. Condenser fans shall be horizontal discharge, with safety guards, statically and dynamically balanced. Fan motors shall have thermal overload protection and shall be furnished with permanently lubricated bearings. All exposed fan and shaft surfaces weatherproofed.

6. Unit shall be provided with a low ambient package that shall include a low ambient controller, evaporator freeze thermostat, isolation relay and other accessories as recommended by the manufacturer.
7. Provide slim line design to fit thru attic access hatch where indicated.

D. CONTROLS

1. The unit controls shall be factory mounted and wired within the outdoor unit casing with an access panel for easy access.
2. The microprocessor shall control the following:
 - a. Compressor anti-recycling protection. Provision shall prevent restarting after shutdown before a safety interval, as determined by the manufacturer. Provision shall be included for fully unloaded start-up.
 - b. Protection against compressor continuously cycling on low pressure control due to low refrigerant charge.
 - c. High pressure switch.

2.4 INDOOR UNIT

- A. Cabinet shall be constructed of galvanized steel panels and coated with baked enamel finish. Lining shall be 1/2" thick minimum conforming to NFPA-90A requirements. Access panels shall be removable for access to filter, coil, electric heater, and fan. Access shall be from the same side as the piping connections. Fasteners shall be manufacturer's standard.
- B. Fans shall be centrifugal, forward-curved, double width, double inlet type and shall be both statically and dynamically balanced.
- C. Fan motors shall be two-speed or three-speed with integral thermal overload protection.
- D. Refrigerant coil shall be grooved copper tubes with mechanically bonded aluminum fins. Provide insulated drain pan under refrigerant coil. Drain pan shall have brass drain connections. Indoor unit shall have sweat connections for refrigerant liquid and suction piping.
- E. Motor shall be approved by an acceptable testing agency.
- F. Factory supplied filter shall be cleanable and shall require no tools for removal.
- G. Unit shall have single point electrical connection and shall be provided with a control transformer.
- H. Provide with manufacturer's condensate pump.

2.5 REFRIGERANT COMPONENTS

- A. Refrigerant system shall include liquid line solenoid valve, biflow filter dryer, biflow thermal expansion valve and a safety relief device. Refrigerant shall be R-410A. Outdoor unit shall be provided with brass service valves.
- B. Refrigerant package shall be copper tubing with an insulated suction line.

2.6 THERMOSTAT

- A. Provide manufacturer's thermostat.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide initial charge of refrigerant and oil.
- B. Install in accordance with manufacturer's written instructions. Systems with long-line refrigerant piping runs shall be provided as recommended by the manufacturer for this application.
- C. Refrigerant lines shall be sized as recommended by the equipment manufacturer to meet the scheduled capacities.

3.2 SCHEDULE: See schedule on drawings.

END OF DUCTLESS SPLIT SYSTEMS

SECTION 15700

HEATING, VENTILATING, AND COOLING SYSTEM

PART 1 - GENERAL

1.1 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
1. Association of Home Appliance Manufacturers (AHAM)
 2. Air Movement and Control Association, Inc. (AMCA)
 3. American National Standards Institute (ANSI)
 4. Air-Conditioning and Refrigeration Institute (ARI)
 5. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE)
 6. American Society of Mechanical Engineers (ASME)
 7. American Society of Sanitary Engineering (ASSE)
 8. American Society for Testing and Materials (ASTM)
 9. ETL Testing Laboratories (ETL)
 10. Foundation for Cross-Connection Control and Hydraulic Research (FCCCHR)
 11. Gas Appliance Manufacturers Association (GAMA)
 12. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
 13. National Electrical Manufacturers Association (NEMA)
 14. National Fire Protection Association (NFPA)
 15. National Roofing Contractors Association (NRCA)
 16. Sheet Metal & Air Conditioning Contractors' National Association, Inc. (SMACNA)
 17. Underwriters Laboratories Inc. (UL)

1.2 SYSTEM DESCRIPTION

Provide new and modify existing heating, ventilating, and cooling (HVAC) systems complete and ready for operation. HVAC systems include equipment, ducts, and piping which is located within, on, under, and adjacent to buildings.

1.3 SUBMITTALS

Submit the following in accordance with section entitled Section 01300 "SUBMITTALS".

A. Manufacturer's Catalog Data

1. Split-system air-conditioners
2. Packaged air-handling units
3. Cabinet unit heaters
4. Unit heaters
5. Exhaust fans
6. Diffusers, registers, and grilles
7. Fire dampers
8. Specialty Valves
9. Dielectric Connections

B. Instructions

1. Installation manual
 - a. Installation Manual

Provide for each item of equipment.

C. Statements

1. Certification of welders' qualifications
 - a. Certification of Welders' Qualifications

Submit copy of Welder Qualification Tests (Form QW-482) prior to site welding. Certification shall not be greater than one year old.
2. Equipment field test plans
 - a. Equipment Field Test Plans

Submit within 120 calendar days after contract award for the following equipment. Submit equipment field test plans to Architect for review and approval.

 - (1) Air-handling units: packaged; greater than 2,000 cfm.
 - (2) Variable air volume (VAV) terminals and related air-handling unit.

D. Field Test Reports

1. Packaged air-handling units: greater than 2,000 cfm

Submit field test reports to Architect for review and approval.

E. Certificates

1. Fire dampers

F. Operation and Maintenance Manuals

1. Split-system air-conditioners
2. Packaged air-handling units
3. Variable air volume (VAV) terminals. Submit with respective air-handling unit.
4. Exhaust fans

Submit in accordance with Section "OPERATION AND MAINTENANCE DATA".

PART 2 - PRODUCTS

2.1 EQUIPMENT

Equipment using refrigerants R-11, R-12, R-113, R-114, R-115, R-500, or refrigerants with ozone depletion factor (ODF) greater than 0.05 shall not be permitted.

A. Split-System Air-Conditioners

Provide units factory assembled, designed, tested, and rated in accordance with ARI 210/240 or ARI 360 for cooling. Provide separate assemblies designed to be used together. Base ratings on the use of matched assemblies. Units shall have a minimum SEER as specified on the drawings when tested in accordance with ARI 210/240 or ARI 360 as applicable. Units shall be ARI certified or rated in ARI UD for cooling. Outside unit shall include compressor and condenser. Provide guards to protect condenser fins. Units shall be listed in UL EAUED or ETL DLP.

1. Filter section: Provide UL listed, 2 inch thick 30 percent efficient throwaway fiberglass filters, standard dust-holding capacity, 350 fpm fiberglass filters, maximum face velocity.
2. Safety controls: Provide low refrigerant pressure protection and pressure relief device. Provide compressor motor with thermal and overload protection, 5 minute anti-recycle timer, and start capacitor kit. Provide compressor with electrical crankcase heater and internal high pressure protection. The above safety controls are not required when scroll compressors are provided.
3. Space temperature controls: Provide digital electronic controls including adjustable programmable thermostats with COOL-OFF-HEAT system switch and AUTO-ON fan switch. Thermostats shall be provided by unit manufacturer.

Provide relays, transformers, contactors, and control wiring between thermostats and unit.

4. Special corrosion protection: Provide condenser coils constructed of copper tubes and plate copper fins or copper tubes and plate aluminum fins with phenolic coating factory applied to entire coil by immersion dipping and baking to 1.5 mil minimum dry film thickness. Rating of units shall be prior to application of phenolic coating.

B. Packaged Air-Handling Units

Provide units factory assembled, designed, tested, and rated in accordance with ARI 430. Units shall be ARI certified for cooling. Provide heating and cooling units including hot water coils and direct expansion refrigerant coils with expansion devices and solenoid valves. Unit shall include fan section, coil section with drain pan, variable frequency motor controller, filter section and access panels. Insulate interior of casing with manufacturer's standard insulation. Provide nylon bushings for dampers.

1. Fan section: Provide draw-through fan section including motor, starter, and drives. Provide adjustable sheaves to permit fan capacity variation from 5 percent above to 5 percent below rated capacity. Provide fan with discharge dampers or variable inlet vanes as indicated.
2. Coil section: Provide ARI 410 coils and slope for drainage. Provide insulated drain pans under cooling coils and valves. Provide direct expansion refrigerant coils with holding charge of dry nitrogen and seal.
3. Filter section: Provide UL listed, 2 inch thick 30 percent efficient throwaway fiberglass filters, standard dust-holding capacity, 350 fpm maximum face velocity. Provide gasketed hinged access panel with quick opening half-twist latches at end of filter rack.
4. Space temperature controls: Provide controls under Section 15901, "SPACE TEMPERATURE CONTROL SYSTEMS".
5. Weatherproof casing: Provide removable gasketed panels designed to exclude driving rain for access to fans, coils, filters, compressors, motors, and controls. Provide weatherproof outside air intake louvers or weatherproof hoods with moisture eliminators.
6. Roof curbs: Provide factory-fabricated galvanized steel roof curbs, wood nailers, insulation, and seal strips in accordance with NRCA RWM curb details for rooftop air-handling units. Roof curbs shall be furnished by unit manufacturer.
7. Equipment selection: Air-handling unit (AHU) manufacturer shall certify the capability of the AHU to perform between the cumulative design minimum and maximum airflows of the variable air volume (VAV) terminals. The AHU submittal selection shall be supported by fan curves clearly annotated showing operating points of the minimum and maximum airflow of connected VAV terminals.

C. Shutoff Boxes

1. General: Furnish and install air terminal units with an integral discharge sound attenuator, primary damper, noise shroud, damper actuator, and velocity controller.
2. Base Unit: The unit casting shall be fabricated from minimum 22 gauge zinc coated sheet steel and use mechanical locking seams to form a leak resistant assembly. Sealant approved for duct use and conforming to NFPA 90A shall be used during construction of the assembly between mating sheet metal parts. The box discharge connection shall be Slip & Drive and shall be integral with the box casing. The casing of the box shall be internally lined with the Anemostat "Fibre-Lok" system, consisting of thermal/acoustical glass fiber with an aluminum laminate facing, minimum 1" thick, with a density not less than 4 1/4 pounds per cubic foot. The aluminum facing shall be exposed to the air stream to prevent airborne fibres. The edges of the insulation shall be sealed by zinc coated steel channels that interlock the adjacent edges of the insulation. The insulation shall conform to NFPA 90A, UL 181, and ASTM C665.

The damper assembly shall consist of a single elliptical blade that requires nominal 60°F rotation from fully opened to fully closed positions. The damper blade shall be mechanically attached to a shaft with either threaded fasteners, or welded. Rivets are not acceptable. The shaft must be a continuous, singular piece running the full inlet diameter and extending through the casing. The damper shall have a tear resistant neoprene lip seal around its perimeter to form a tight air seal for full shut-off. Seals other than neoprene are not approved. The damper shaft shall rotate in nylon, self-lubricating bearings. Damper position shall be indicated on the end of the shaft on the outside of the casing.

3. Hot Water Coils: Where shown on the plans, hot water heating shall be provided by the unit manufacturer. The hot water coils shall be mounted at the discharge of the air terminal unit by the terminal manufacturer, and the air terminal unit/coil assembly shall have a Slip & Drive connection for attachment to the downstream duct work. Coils shall be 1/2" copper tubing mechanically expanded in aluminum fins (not less than 10 fins/inch) to form a tight thermal bond. Refer to the heating schedule for capacities and performance requirements. Sequencing of the primary air flow and water valves shall be coordinated between the air terminal unit manufacturer and the controls contractor. Water control actuators and valves shall be furnished and installed under Section 23 09 23 of the specifications.
4. Sound Levels: Air terminal unit sound power levels shall have been tested in accordance with the most recent ARI 880 test method. Discharge sound levels shall not exceed NC 30 at 0.20 inches w.g. inlet static pressure with 10 DB room absorption. Radiated sound levels shall not exceed NC 25 at 0.20 inches w.g. inlet static pressure. Scheduled Radiated NC levels include attenuation credit for 10 db room absorption and single pass transmission loss through an acoustical ceiling.

D. Cabinet Unit Heaters

Provide units factory assembled, designed, and tested. Units shall include single heating hot water or steam coil, centrifugal fans, three-speed split capacitor motors with integral thermal overload protection, and filters.

1. Filters: Provide UL listed throwaway fiberglass filters, standard dust-holding capacity.
2. Space temperature controls: Provide controls including adjustable room temperature control thermostats with VENT-OFF-HEAT system switch, HIGH-MEDIUM-LOW fan switch, and FAN ONLY switch. When system switch is in OFF position, deenergize automatic valve to stop water flow to coil. Thermostats shall be furnished by unit manufacturer and installed where indicated. Provide relays, transformers, contactors, and control wiring between thermostats, and unit.
3. Horizontal units: Provide concealed, recessed, and cabinet units where indicated.
 - a. Concealed units: Provide unit mounted filter box with track and hinged access doors with latches. Provide supply air discharge with one inch duct collar. Provide return air plenum suitable for bottom or rear return air duct connection as indicated. Provide plenum with duct lining.
 - b. Recessed units: Provide adjustable recessing frame for flush ceiling mounting. Provide hinged bottom panel with latches for access to filters and fan motors. Provide discharge air outlet with one inch duct collar. Provide bottom access panel with stamped return air grille or provide solid bottom access panel and rear return air inlet with one inch duct collar as indicated.
 - c. Cabinet units: Provide hinged bottom panel with latches for access to filters and fan motors. Provide adjustable double deflection or stamped discharge grilles as indicated. Provide bottom or rear stamped return air grille as indicated.
4. Vertical units: Provide recessed and cabinet units where indicated. Provide unit levelers, subbases, and removable front cover for access to filters and fan motors. Provide outside air intake boxes with manual dampers and weatherproof anodized aluminum louvers.
 - a. Recessed unit: Provide removable front cover for access to entire unit. Provide discharge air and return air grilles in front cover.
 - b. Cabinet unit: Provide removable front, side, and top panels. Provide adjustable double deflection or stamped discharge grille as indicated.

E. Unit Heaters (Hot Water)

Provide factory-assembled, propeller or blower type fan unit heaters arranged for horizontal or vertical air discharge as indicated. Each unit shall include steam or hot water coil, fan, electric motor, housing, and air discharge vanes or diffusers. Horizontal discharge type units shall have adjustable deflectors for control of horizontal and vertical airflow. Rotating air deflector assemblies on vertical units where indicated shall be gear driven by separate electric motor and shall rotate when the fan runs. Each unit shall be provided with threaded mounting holes for attaching threaded hanger rods. Fan motor shall be controlled by wall-mounted adjustable thermostat with higher end of scale range

factory set at 75 degree F. Controls shall be automatic of the on-off type. Provide fan selector switches to provide AUTOMATIC-ON-OFF positions.

F. Unit Heaters (Electric)

1. Acceptable Manufacturers

- a. Markel
- b. Modine
- c. Chromolox

2. Construction

- a. Heavy gauge die formed steel housing.
- b. Completely enclosed fan motor and motor guard.
- c. Individually adjustable discharge louvers.
- d. Aluminum finned, copper clad steel sheath heating element.
- e. Low voltage controls complete with 24 V control transformer if required.
- f. Automatic reset thermal cutout, capillary type.
- g. Fan time delay at off cycle to dissipate heat from elements.
- h. UL listed.
- i. Disconnect switch, non-fused, interlocking and meeting NEC requirements.
- j. Integral or remote thermostat as indicated.

G. Exhaust Fans

1. Centrifugal Exhaust Fans (Wall or Roof)

ANSI/AMCA 210 with AMCA seal. Provide centrifugal type exhaust fans with aluminum housing, fan wheel, and bird screen. Motors shall be completely shielded from the airstream. Provide exhaust opening and gravity closing type automatic backdraft dampers. Provide NRCA RWM roof curb for roof mounted exhaust fans as recommended by fan manufacturer. Provide with disconnect and speed controller. Provide v-belt or direct drive exhaust fans as indicated.

2. Utility Set(s)

ANSI/AMCA 210 with AMCA seal. Provide single width, single inlet blower with backward inclined, non-overloading centrifugal wheel constructed of heavy gage

steel. The housing shall be of heavy gage steel with airtight lock seam construction. Provide a weatherhood to protect the motor and drive. Provide direct drive or v-belt driven exhaust fans as indicated. Belt driven fans shall be provided with an adjustable motor plate. Provide with disconnect, manual starter switch, vibration isolators, and backdraft damper.

2.2 ELECTRICAL

A. Electrical Motors, Controllers, Contactors, and Disconnects

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall conform to Division 16 Electrical. Provide electrical connections under Division 16 Electrical. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section.

B. Electrical Work

Provide under Division 16 Electrical. Provide control wiring under Section 15970, "DIRECT DIGITAL CONTROL SYSTEMS".

2.3 METAL DUCT SYSTEMS

Provide shop-fabricated, zinc-coated steel ducts conforming to ASTM A 653/A 653M coating designation G90. Fabricate, construct, brace, reinforce, install, support, and seal ducts and accessories in accordance with SMACNA DCS. Provide rectangular ductwork for low pressure applications; round and flat oval ductwork for medium and high pressure applications as indicated. Cover duct transverse joints with single component synthetic rubber type compound suitable for use with passivated coating on zinc-coated steel. Lap joints in direction of flow. Provide ducts straight and smooth on inside with neatly finished airtight joints. Provide air supply and return openings in ducts with air diffusers, registers, or grilles.

A. Ducts of Pressure Classes 3 to 10 WG

Construction ducts of galvanized steel.

1. Construction

Duct construction, metal gages, and hangers and support reinforcements shall conform with the SMACNA DCS. Ducts shall not pulsate or vibrate when in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork. Air leakage shall be less than one percent of the system capacity. Curved elbows shall have a centerline radius not less than 1 1/2 times the width of ducts.

2. Joints

Construct joints to meet the requirements of the leakage test specified herein. Duct components shall fit so that joints are not mismatched. Do not use duct sealant and tape to compensate for mismatched connections. Longitudinal locks or seams known as "button-punch snap-lock" will not be permitted. Apply fire-resistant sealing compound to exposed male part of fittings collars so that sealer

will be on inside of joint and fully protected by the metal of the duct and fittings. Apply one brush coat of sealing compound over outside of joint to at least 2 inch band width covering screw heads and joint gap. When tape is used, apply a single wrap of a duct tape over the wet sealer. Tape provided shall be recommended by the sealer manufacturer to permit proper curing of the sealer. Dents in the male portion of the slip fitting collar will not be acceptable.

3. Fittings

Square elbows, round elbows, fittings, branch take-offs, transitions, splitters, duct volume dampers, fire dampers, flexible connections, and access doors shall conform with the SMACNA DCS, Section 2.

- a. Test holes: Provide factory fabricated, airtight, and noncorrosive test holes with screw cap and gasket. Provide extended neck fittings to clear insulation.
- b. Round elbows: Provide 45 degree and 90 degree round elbows of two piece die stamped construction for ducts 8 inches or less in diameter. For ducts over 8 inches in diameter, provide 5 mitered piece for 90 degrees and 3 mitered piece for 45 degrees.

4. Round and Oval Ducts

SMACNA DCS, Section 3.

5. Medium - High Pressure Single Wall, Round And Flat Oval Spiral Duct And Fittings

- a. Gauges and construction per SMACNA Duct Construction Standards - Metal and Flexible.
- b. Fiberglass insulation thickness 1 inch.
- c. Fiberglass liner to have protective membrane on air stream side to provide positive barrier against glass fiber entrainment.
- d. Slip joint construction.
- e. 90 Degree elbows to be 5 piece welded or 2 piece die formed where available.
- f. 45 Degree elbows to be 3 piece welded or 2 piece die formed where available.
- g. Tees and crosses to be conical type.
- h. Take off from rectangular duct to use bell mouth fitting.
- i. Provide from air handling unit discharge to inlet of fan powered mixing terminal.

6. Medium – High Pressure Double Wall, Round And Flat Oval Spiral Duct And Fittings
 - a. Gauges and construction per SMACNA Duct Construction Standards - Metal and Flexible with perforated interior sheet metal wall.
 - b. Fiberglass insulation thickness 1 inch.
 - c. Fiberglass liner to have protective membrane on air stream side to provide positive barrier against glass fiber entrainment.
 - d. Slip joint construction.
 - e. 90 Degree elbows to be 5 piece welded or 2 piece die formed where available.
 - f. 45 Degree elbows to be 3 piece welded or 2 piece die formed where available.
 - g. Tees and crosses to be conical type.
 - h. Take off from rectangular duct to use bell mouth fitting.
 - i. Provide from air handling unit discharge to inlet of fan powered mixing terminal.

7. Medium –High Pressure Rectangular Ducts

Make joints between sections of duct and between ducts and fittings with either gasketed flanged connection, welded flange joints, or other joints recommended in SMACNA DCS, Section 1, and reinforce at the joints and between the joints as recommended. Construction to match connected round and oval duct systems.

B. Ducts of Pressure Classes Up To 3 Inch WG

Construction, metal gage, hangers and supports, and reinforcements shall conform with SMACNA DCS, except that ducts with pressure classifications below 2 inch water gage that are located outside of the conditioned space shall have a seal Class B. Ductwork shall be airtight and shall not vibrate or pulsate when system is in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork with pressure classifications above one inch water gage. Air leakage shall be less than 5 percent of the system capacity. Construct ductwork of galvanized steel.

1. Curved Elbows

Make a centerline radius not less than 1 1/2 times the width or diameter of the duct.

2. Laps

Make laps at joints in the direction of airflow. Space button-punch or bolt-connection in standing seams at fixed centers not greater than 6 inches. Longitudinal locks or seams, known as "button-punch snap lock," may be in lieu of Pittsburgh Lock.

3. Fittings

Elbows, vanned elbows, take-offs, branch connections, transitions, splitters, volume dampers, fire dampers, flexible connections, and access doors shall conform with SMACNA DCS, Section 2. Provide factory fabricated, airtight, and noncorrosive test holes with screw cap and gasket.

C. Acoustical Attenuator Systems

1. Acoustical Duct Lining

Provide where indicated. Provide ASTM C 1071 fiberglass duct lining, minimum of one inch thick, with black-pigmented fire-resistant coating on side exposed to airstream. Secure to duct interior with 100 percent coverage of adhesive and with mechanical fastening devices, spaced in accordance with SMACNA DCS. Provide metal nosing at duct lining beginnings and endings.

2. Net Noise Reduction Values

Conform with the following:

Minimum Net Noise Reduction Values

Sound Pressure Level dB

(Reference Sound Power at 10-12 Watts)

Octave Pass Band	2	3	4	5	6	7	
Center Frequency (Hz)	125	250	500	1000	2000	4000	
Noises Reduction (db)	11	16	19	30	40	32	

3. Preformed Duct Liner

Provide preformed round duct liner minimum of one inch thick, with black-pigmented fire-resistant, anti-microbial agent designed for insertion in round ducts may be used in the sizes commercially available. Provide duct liner sections with slip-lap joints not less than 2 inches wide. Make joints in accordance with manufacturer's printed instructions. Furnish fire-resistant adhesive to field-coated joints when recommended by the manufacturer to prevent delamination or erosion at joints. Tabular sections of duct liner shall fit the metal duct snugly and without gaps between duct-liner sections.

D. Laboratory / Chemical Fume Hood Exhaust Ducts

1. Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.

- OR -

2. PVC Coated Duct: Duct internally coated with PVC may be furnished in lieu of stainless steel for laboratory fume hood exhaust duct.
 - a. Duct shall be galvanized sheet steel, ASTM A527, coating G90, coated inside before fabrication with four mil dry film thickness of polyvinyl chloride (PVC) plastic suitable for temperature to 120 degrees C (250 degrees F). Material shall comply with UL 181, Class 1 (flame spread rating of not more than 25 and a smoke developed rating of 50 or less in accordance with ASTM E84). Duct exterior may be uncoated or coated with PVC. Provide compatible joint sealant and material for field coating of damaged areas.
 - b. Damper frames, damper blades and shafts, shall be stainless steel or PVC coated galvanized steel, with non-ferrous bearing material.

E. Flexible Duct Connectors

Provide a minimum of design pressure rated plus 5.0 inch W.G. static pressure airtight flexible duct connectors at duct connections to each air-conditioning unit, air-handling unit, exhaust fan, and ventilating fan. Support connectors at each end with metal angle frame bands, securely bolt in place. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene.

F. Turning Vanes

Provide fabricated tees and square elbows with double walled turning vanes in accordance with SMACNA DCS for vaned elbows.

G. Dampers

Provide factory manufactured opposed blade adjustable manual dampers where indicated for duct heights of 12 inches and larger. Provide factory manufactured single leaf dampers for duct heights less than 12 inches. Provide damper shafts with 2 inch standoffs to clear 2 inches of duct insulation with bearings at both ends of the shafts. Provide adjustment quadrant with indicator and locking devices. Provide galvanized steel dampers 1 gage heavier 10.006 inch than duct in which dampers are installed.

H. Diffusers, Registers, and Grilles

Provide factory-fabricated metal units with edges rolled or rounded where exposed to view, and factory primed with off-white enamel finish. Provide each diffuser and register with factory-fabricated, group-operated, adjustable, opposed-blade, air-volume-control dampers, key or screwdriver operated from the face of unit. Provide each unit with

rubber or plastic installation gaskets. Diffusers in same room shall have same face design.

1. Diffusers: Provide round, square, or rectangular diffusers as indicated. Ceiling diffusers shall be designed to deliver air in a horizontal direction. Provide baffles or other devices as required for proper air distribution pattern. Provide 4-way pattern unless otherwise noted on contract drawings.
2. Registers: Provide double deflection supply registers arranged to control air direction, throw, and drop. Exhaust and return air registers shall have single set of nondirectional face bars or vanes having the same appearance as supply registers. Provide face bars or vanes spaced not more than 0.75 inch on center and not less than 0.62 inch depth.
3. Grilles: Provide as specified for registers without air-volume-control dampers.

I. Access Doors

Provide for access to volume dampers, fire dampers, plenum chambers, and where indicated. Provide each door with double wall zinc-coated steel construction, gasketed airtight, with continuous hinges and cam latches. Insulate access doors with one inch thick rigid insulation. Provide 12 inch by 12 inch door, except where larger sizes are indicated, or provide 12 inches by height of duct when duct is less than 12 inches high. Provide keyed-alike 90 degree turn cam locks on each access door in sleeping rooms; furnish three keys.

J. Fire Dampers

UL 555 and NFPA 90A. Dampers shall be listed in UL BMD. Dampers when open shall not protrude into the ducts. Dampers shall be dynamic rated.

K. Flexible Round Ducts (see Execution section for limitations on use)

UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Fire hazard rating of duct assembly shall not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches W.G. positive and 1.5 inches W.G. negative. Flexible round duct length shall not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

1. Inner duct core: Flexible core shall be interlocking spiral or helically corrugated and constructed of zinc-coated steel, aluminum, or stainless steel; or shall be constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.
2. Insulation: Inner duct core shall be insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Insulation shall be covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.4 PIPING SYSTEMS

Provide the following pipe and fittings. Provide dielectric fittings, unions or flanges between steel piping and copper tubing for all piping sizes; except that copper alloy valves and strainers may be used without dielectric fittings, unions or flanges. Water piping sizes 4 inches and smaller shall be copper tubing. Water piping sizes larger than 4 inches shall be copper tubing or steel piping.

A. Soldered Joint Copper Tubing

Provide ASTM B 88, Type L or M for aboveground piping, Type K for buried piping, with ANSI B16.18 or ASME/ANSI B16.22 solder joint fittings, unions, and flanges; provide adapters as required. Provide ASTM B 42 copper pipe nipples with threaded end connections. Provide ASTM B 32, 95-5 tin-antimony solder, or provide Plumbing Code approved lead-free solder.

B. Grooved-End Copper Tubing System

Grooved-end copper tubing system may be provided in lieu of soldered joint copper tubing for water piping located within the mechanical equipment rooms and aboveground exterior of the buildings for pipe sizes 2 through 6 inches. Provide grooved-end mechanical couplings of the rigid type including EPDM gaskets and copper fittings supplied by the same manufacturer for pipe sizes 2 through 6 inches.

1. Copper Tubing

ASTM B 88, Type M with rolled grooved end connections.

2. Copper Fittings

Copper alloy shall conform to ASTM B 75 C12200, ASTM B 152 C11000, ANSI B16.18, or ASME/ANSI B16.22 for factory rolled grooved copper alloy tees, elbows, and reducers.

3. Gasketed Mechanical Couplings

ASTM F 1476 for use with rolled grooved copper tubing and rolled grooved copper alloy fittings. Provide ASTM A 536 rigid type couplings which do not permit expansion or contraction, EPDM gaskets, and ASTM A 183 bolts and coupling nuts. Provide flanged adapters as required for connections to ASME Class 125 and 150 flanges on valves and equipment.

C. Copper Tubing Piping Systems

Provide copper tubing for the following piping systems, except water piping sizes larger than 4 inches shall be copper tubing or steel piping.

1. Chilled water, chilled-hot water, and hot water piping.

2. Cold drain piping from drain pans.

3. Fuel oil supply and return piping with ASME/ANSI B16.26 flared fittings or compression type fittings.

D. Copper Cold Drain Piping

Provide copper tubing in accordance with paragraph entitled "Copper Tubing" for Piping Sizes One Inch and Smaller." Provide ASTM B 306 copper tubing and ANSI B16.23 solder joint fittings for piping sizes larger than one inch. In lieu of copper tubing, 1.25 inch Schedule 40 polyvinyl chloride (PVC) plastic pipe, fittings, and solvent cement may be provided.

E. Copper Refrigerant Tubing

Provide ASTM B 280, cleaned, dehydrated, and sealed. Provide ASME/ANSI B16.22 solder joint refrigerant fittings and adapters. Provide silver brazing alloy solder and silver brazing alloy flux. During brazing operations bleed a small amount of dry oil-free nitrogen continuously through the refrigerant tubing. Provide ASME/ANSI B16.26 flared fittings.

F. Dielectric Connections

Provide at connections between copper and ferrous metal piping materials. ASTM F 441/F 441M, Schedule 80, CPVC threaded pipe nipples, 4 inch minimum length, may be provided for dielectric connections in pipe sizes 2 inches and smaller.

G. Valves

Valves shall have flanged end connections, except valves smaller than 2.5 inches may have threaded end connections with a union on one side of the valve. Solder end connections may be used for connections between copper alloy valves and copper tubing.

1. Gate Valves

MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-70, Class 125.

2. Globe and Angle Valves

MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-85, Class 125.

3. Check Valves

MSS SP-80, Class 125, swing check; except sizes 2.5 inches and larger shall conform to MSS SP-71, Class 125.

4. Butterfly Valves

MSS SP-67, except sizes 2.5 inches and larger shall have lugged or wafer body designed for installation between ASME Class 150 flanges. Valves shall have two-position lever handles.

5. Ball Valves

Full port design, copper alloy body, except sizes 2.5 inches and larger shall be cast-iron body. Valves shall have two-position lever handles. Ball valves may be provided in lieu of gate valves.

6. Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

7. Air Venting Valves

Provide copper alloy body valves with automatic or manual air vent as indicated.

H. Specialty Valves

1. Combination Pressure and Temperature Relief Valves

ANSI Z21.22, copper alloy body, automatic reseating, test lever, and discharge capacity based on AGA temperature steam rating.

2. Water Pressure Reducing Valves

ASSE 1003, copper alloy body, automatic reseating, with test lever.

3. Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

4. Flow Control Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts, and integral pointer that indicates the degree of valve opening. Valves shall be suitable for 125 psig at 190 degrees F hot water. Valve shall function as a service valve when in fully closed position. Valve body shall have factory-installed tapings for differential pressure meter connections for verification of pressure differential across valve orifice. Meter connections shall have positive check valves or shutoff valves. Each valve shall have metal tag showing the gallons per minute flow for each differential pressure reading.

5. Backflow Prevention Assemblies

Provide reduced pressure principle type backflow prevention assemblies which are approved by and has a current "Certificate of Approval" from the FCCCHR-USC. Listing of the particular make, model/design, and size in the current FCCCHR-USC will be acceptable as the required proof.

6. Refrigerant Valves

ASME/ANSI B31.5, and shall be copper alloy. Provide valves in each system for servicing and for isolating system components in compliance with ASHRAE 15.

2.5 PIPING ACCESSORIES

A. Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

B. Strainers

Pressure and temperature range shall be for the intended service. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. Provide stainless steel strainer element with perforations of 0.047 inch for water, 0.031 inch for steam mixed with condensate, and 0.016 inch for steam. Provide copper alloy or cast-iron body strainers in steam and condensate systems up to 100 psig. Provide steel body strainers in steam and condensate systems 100 psig and greater.

C. Traps

Provide traps of the types indicated with stainless steel internals. Pressure and temperature range shall be for the intended service. Traps for steam at 100 psig and greater shall be minimum of ASME Class 150.

D. Pressure Gages

Provide single style pressure gage with 4.5-inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range for intended service.

E. Thermometers

Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 3 inch diameter dial with glass face gasketed within the case; and accuracy within 2 percent of scale range. Provide scale range for intended service.

F. Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors. Provide 1-inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

1. Sleeves in Masonry and Concrete

Provide steel pipe sleeves or Schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2. Sleeves not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

G. Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid where indicated. Connectors shall be suitable for the intended service.

H. Sight Glass and Refrigerant Drier

ARI 710. Provide in refrigerant liquid piping.

2.6 ACCESS DOORS FOR VALVES

Provide factory-prefabricated and primed flush face steel access doors including steel door frame for with continuous hinges and turn-screw-operated latch. Provide door frame installation in plaster and masonry walls. Furnish doors under this section; install doors under appropriate section of this specification.

PART 3 - EXECUTION

3.1 INSTALLATION

A. HVAC System

Installation of HVAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1, ASME/ANSI B31.5, NFPA 70, and in accordance with the manufacturer's recommendations.

B. Connections to Existing Systems

Notify the Owner's Representative in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.2 PIPING

Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted. Install valves with stems horizontal or above.

Provide flanges or unions at valves, traps, strainers, and connections to equipment; unions are not required in copper tubing piping systems.

- A. Threaded connections: Provide Teflon pipe thread paste on male threads. Do not thread metal pipe into plastic piping.
- B. Pipe hangers and supports: Provide additional pipe hangers and supports at in-line water pumps and flanged valves.
- C. Piping to receive insulation: Provide temporary wood spacers between the pipe hangers and supports, and the pipe to properly slope the piping and establish final elevations. Provide temporary wood spacers of same thickness as insulation to be provided under Section 15250, "INSULATION". Support plastic piping every 4 feet. Support metal piping as follows:

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	3.5	4	5	6
Copper Tubing	6	7	8	8	9	10	11	12	13	14
Steel Pipe	7	8	9	10	11	12	13	14	16	17

- D. Cleaning of piping: Keep interior and ends of new piping and existing piping affected by Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.
- E. Demolition: Remove materials so as not to damage materials which are to remain. Replace existing work damaged by Contractor's operations with new work of same construction.
- F. Tee Joints: Extracted tee joints may be made in copper tube. Make joint with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. Notch the branch tube for proper penetration into fitting to ensure a free flow joint. Braze extracted joints using a copper phosphorous classification brazing filler metal. Soldered joints shall not be permitted.
- G. Tracer Wire
Provide metallic tracer wire for all underground buried piping.

3.3 ADJUSTMENTS

Adjust controls and equipment so as to give satisfactory operation. Adjust entire water temperature control system and place in operation so that water quantities circulated are as indicated. Air duct systems shall be adjusted and balanced so that air quantities at outlets are as

indicated and so that distribution from supply outlets is free from drafts and has uniform velocity over the face of each outlet.

3.4 INSTRUCTING OPERATING PERSONNEL

Upon completion of work and at time designated by Owner's Representative, provide services of competent technician for period of not less than one 8-hour working day for instruction of Government operating personnel in proper operation and maintenance of equipment.

3.5 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each system in service to demonstrate compliance with the contract requirements. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided by Contractor and repeat tests. Furnish steam, fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, ducts, and filters.

A. Piping Systems Except for Refrigerant Piping

Before insulating, hydrostatically test each new piping system at not less than 188 psig; except pneumatically test fuel oil storage tank and fuel piping system at not less than 5 psig for tank and 50 psig for piping. Maintain pressure for 2 hours with no leakage or reduction in gage pressure. Obtain approval before applying insulation.

B. Refrigerant Piping

Perform following when field piping connections are provided.

1. Pressure test: Test refrigerant piping using dry, oil-free nitrogen, and prove tight at 300 psig on the high side and 150 psig on the low side. Maintain pressure for 2 hours with no leakage or reduction in gage pressure.
2. Evacuation: Using high vacuum pump and certified micron gage, reduce absolute pressure on both sides of system simultaneously to 300 microns. After reaching this point charge system with proper refrigerant until pressure of zero psig is obtained. Repeat evacuation-charging procedure for two more cycles, totaling to three evacuation-charging cycles. On final evacuation, secure pump and maintain 300 microns for 2 hours before charging with required final refrigerant.

C. Air Ducts

Obtain approval before applying insulation.

1. Connect ceiling supply diffusers to low pressure duct with a maximum of 5 feet of flexible duct. Ensure smooth radius bends with proper support. Other uses of flexible duct are not permitted.

D. Equipment

1. Field Testing

Test each item of equipment in operation for continuous period of not less than 24 hours under every condition of operation in accordance with each equipment manufacturer's recommendation. Verify that the equipment operating parameters are within limits recommended by the manufacturer.

2. Equipment Requiring Field Test Plans

Furnish equipment field test plans developed by each equipment manufacturer detailing recommended field test procedures for each item of equipment. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment will not be acceptable. The Owner's Representative will review and approve the field test plan for each item of equipment prior to commencement of field testing of the equipment.

- a. Equipment items to test: Equipment requiring field test plans are listed in paragraph entitled "Statements."
- b. Coordinated testing: Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of equipment controls which interlock and interface with controls factory prewired or external controls for the equipment provided under Section 15970, "DIRECT DIGITAL CONTROL SYSTEMS".
- c. Prerequisite testing: Equipment for which performance testing is dependent upon the completion of the work covered by Section 15030, "ADJUSTING, BALANCING AND SYSTEM TESTING" must have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.
- d. Test procedure: Indicate in each field test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer. Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control. Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.
- e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Manufacturer shall furnish with each test procedure a description of acceptable results that have been verified. Manufacturer shall identify the acceptable limits or

tolerances within which each tested performance variable shall acceptably operate.

- f. Job specific: Each test plan shall be job specific and shall address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3. Equipment Requiring Field Test Reports:

- a. Equipment items for reports: Equipment requiring field test reports are listed in paragraph entitled "Field Test Reports."
- b. Manufacturer's recommended test: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field testing.
- c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.
- d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Owner's Representative in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
- e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director and the QC manager. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.
- f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

END OF HEATING, VENTILATING, AND COOLING SYSTEM

SECTION 15860
SHEET METAL ACCESSORIES

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this section.

1.2 WORK INCLUDED

- A. Access doors.
- B. Fire/smoke dampers.
- C. Balancing dampers.
- D. Flexible duct connections.
- E. Backdraft dampers.

1.3 QUALITY ASSURANCE

- A. Fire and smoke dampers shall be U.L. listed and constructed in accordance with U.L. Standards 555 and 555S, smoke dampers.
- B. Fusible links on fire and smoke dampers shall be constructed to U.L. Standard 33, Fusible Links for Fire Protection Service.
- C. Demonstrate re-setting of fire dampers to authorities having jurisdiction and Owner's representative.
- D. Access doors shall be U.L. labeled.

1.4 SUBMITTALS

- A. Comply with Section 15000, Mechanical General Provisions.
- B. Manufacturer's Data:
 - 1. Access doors.
 - 2. Fire/smoke dampers.
 - 3. Balancing dampers.
 - 4. Flexible duct connections.
 - 5. Backdraft dampers.

C. Operation and Maintenance Manuals:

1. Fire dampers
2. Motorized dampers

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Access Doors

1. Air Balance, Inc.
2. Ruskin
3. Ventfabrics, Inc.

B. Fire Dampers and Smoke Dampers

1. Prefco
2. Air Balance, Inc.
3. Ruskin
4. Safe Air

C. Balancing Dampers

1. Louvers & Dampers
2. Ruskin
3. Air Balance, Inc.
4. Arrow

D. Flexible Duct Connections

1. Ventfabrics
2. Duro Dyne
3. Cain Manufacturing Co.

E. Motorized Dampers

1. Greenheck
2. Louvers & Dampers
3. Ruskin

- F. Backdraft Dampers
 - 1. Greenheck
 - 2. Ruskin
 - 3. Louvers & Dampers
 - 4. Arrow

2.2 ACCESS DOORS

- A. Fabricate rigid and close-fitting doors of galvanized or stainless steel, to match ductwork, with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.
- B. Provide two hinges and two sash locks for sizes up to 18 inch square, two hinges and two compression latches with outside and inside handles for sizes up to 24 inch x 48 inch. Provide an additional hinge for larger sizes.
- C. Minimum size shall be 10" x 10" unless duct size prohibits, in which case the largest size that the largest duct dimension will accommodate shall be used.

2.3 FIRE AND SMOKE DAMPERS

- A. Fabricate of galvanized steel weighted to close and lock in closed position when released by fusible link. Provide with spring closure (i.e. dynamic rating).
- B. Fire dampers shall be curtain type.
- C. Curtain type fire dampers shall have blades retained in a recess so free area of connecting ductwork is not reduced.
- D. Select fusible links for 160 degree F release.

2.4 SMOKE DAMPERS

- A. 16 gauge galvanized steel channel frame, 16 gauge galvanized steel damper blades.
- B. Smoke dampers shall be parallel blade type with external linkage concealed in frame.
- C. Flexible metal compression type jamb seals.
- D. Provide with 120 volt electric actuator mounted out of the airstream.
- E. Smoke dampers must qualify to and be classified under UL 555S Leakage Class III.

2.5 BALANCING DAMPERS

- A. Fabricate of galvanized steel, minimum 16 gauge and provide with quadrants or adjustment rod and lock screw.
- B. Fabricate single blade dampers for duct sizes to 12 inch x 48 inch.

- C. Fabricate multi-blade damper of opposed blade pattern with maximum blade size 12 inch x 72 inch. Assemble center and edge crimped blade in prime coated or galvanized channel frame with suitable hardware.

2.6 FLEXIBLE DUCT CONNECTIONS

- A. Flexible duct connectors shall be preassembled metal to exposed fabric to metal. Fabric and metal shall be joined by means of a double lock seam. Fabric shall be neoprene and shall be minimum 3 inch width between metal sections.

2.7 APPLICATION

- A. Provide access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire and smoke dampers, and elsewhere as indicated. Review locations prior to fabrication.
- B. Provide fire and smoke dampers at locations shown, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Fire and smoke dampers shall be installed complete with required perimeter mounting angles, sleeves, breakaway duct connections, fasteners, and firestopping materials.
- C. Provide balancing dampers at points on low pressure supply, return and exhaust systems where branches are taken from larger ducts for air system balancing.
- D. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and equipment subject to forced vibration. This includes factory or factory and field fabricated air handling units where flexible connectors are not a part of the package.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install items in accordance with manufacturer's written installation instructions.
- B. Attach flexible duct connectors to ductwork and equipment by screws or bolts at 6 inch intervals and sealant to provide airtight connection. Flexible duct connectors shall be installed to maintain minimum 1.5 inches clearance between metal flanges.

END OF SHEET METAL ACCESSORIES

SECTION 15950
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specification Sections, and Section 15000, "Mechanical General Provisions", apply to work of this Section.

1.2 WORK INCLUDED

- A. It is the Mechanical Subcontractor's responsibility to notify all members of the General Contractor's team of their required participation in commissioning work. Failure to do so will not be an acceptable basis for Change Orders. A separate Commissioning Agent (the Engineer) shall be engaged by the Owner to administer the commissioning of the HVAC system. The Contractor shall provide all commissioning services as outlined in this Section, and coordinate with the Commissioning Agent.

1.3 COMMISSIONING OBJECTIVES

- A. To ensure that all building HVAC systems, subsystems, HVAC equipment, controls, and interfaces with other building systems are installed, tested, and are operating in compliance with contract documents and within the scope of design requirements.
- B. To ensure that all HVAC system operation and maintenance personnel are properly instructed to effectively and efficiently operate and maintain the HVAC systems, subsystems, HVAC equipment, and controls, and that they will receive all required manuals and documentation.

1.4 SUBMITTALS

- A. The Contractor shall submit the following to the Engineer in accordance with Section 01300 procedures, and obtain approval before proceeding with the Work:
 - 1 Commissioning Plan: Prepare and submit with contents as specified herein, for approval.
 - 2 Commissioning Team: List of team members who will represent the Contractor in the pre-commissioning checks and functional performance testing. Proposed revision to the list, prior to the start of the impacted work.
 - 3 Checklists and Test Forms: Pre-Commissioning Checklists and Functional Performance Test Forms, prepared specifically for this project, and edited to suit the equipment and systems installed, submitted for review.
 - 4 Test Schedule: Schedule for pre-commissioning checks and functional performance tests, at least two weeks prior to the start of pre-commissioning checks.

- 5 Commissioning Report: Completed pre-commissioning checklists and functional performance test reports, organized by subsystem, and submitted as one package. The results of failed tests shall be included along with a description of the corrective action taken. Copy of Commissioning Plan, TAB Reports, Drawings, and O&M Manuals shall also be submitted.

1.5 REFERENCED STANDARDS

- A. ASHRAE Guideline 1-1989, "Guideline for Commissioning HVAC Systems".
- B. NEBB, "Procedural Standards for Building Systems Commissioning".
- C. SMACNA, "HVAC Systems Commissioning Manual".

1.6 COMMISSIONING TEAM

- A. The Contractor shall designate team members from each of the following to participate in the Commissioning Process:
 - 1 General Contractor (Quality Control Manager)
 - 2 Mechanical Subcontractor
 - 3 Electrical Subcontractor
 - 4 Testing, Adjusting and Balancing (TAB) Subcontractor
 - 5 Automatic Temperature Controls Subcontractor
- B. Each of the team members shall be identified in the Commissioning Plan.
- C. In addition, the Owner's Commissioning Agent (Engineer) shall be represented.

1.7 SEQUENCING AND SCHEDULING

- A. The work described in this Section shall begin only after all work required in Division has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved.

PART 2 - PRODUCTS

(Not applicable)

PART 3 - EXECUTION

3.1 COMMISSIONING TEAM AND CHECKLISTS

- A. The Contractor shall designate team members to participate in the pre-commissioning checks and the functional performance testing specified herein.

Designation	Function
Q	Contractor's Chief Quality Control Representative
M	Contractor's Mechanical Representative
E	Contractor's Electrical Representative
T	Contractor's Testing, Adjusting, and Balancing Representative
C	Contractor's Controls Representative
O	Owner's Commissioning Agent (Engineer)

- B. Each checklist shown in Appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each pre-commissioning checklist item shall be indicated by initials and date unless an "X" is shown indicating that participation by that individual is not required. Acceptance by each commissioning team member of each functional performance test checklist shall be indicated by signature and date.

3.2 IMPLEMENTATION OF HVAC SYSTEMS COMMISSIONING PLAN

- A. Plan Submittal: As soon as possible after the start of construction, the Contractor shall submit the HVAC Systems Commissioning Plan. The Plan shall provide the scope of HVAC commission tasks to the appropriate parties, review all schedules and contract documents, and assign estimated start dates and durations for:

- 1 Commissioning Agent visits to job site to observe installation activities
- 2 Pre-startup verification
- 3 Submittal of equipment and systems startup verification
- 4 Submittal of testing, adjusting, and balancing (TAB) reports
- 5 Functional performance testing
- 6 Completion of operating and maintenance manuals
- 7 Operation and maintenance personnel instruction
- 8 Submittal of HVAC commissioning report
- 9 Owner acceptance

- B. Equipment and Systems Startup

- 1 Pre-startup Verification: Prior to startup of HVAC equipment and systems, the Contractor shall indicate on the pre-start checklists and Commissioning Agent shall observe and verify that all items have been substantially installed in accordance with the project contract documents, including all change orders. Verification of the basic installation testing of systems includes:
 - a. Cleaning of equipment and systems of construction dirt and debris, including replacement of filters

- b. All items per the approved checklists
- 2 Startup Verification: The Contractor shall indicate on the startup checklists, and Commissioning Agent shall verify that all HVAC equipment, systems, and subsystems have been activated and operate substantially in accordance with contract documents, with all equipment, system, and electrical operating and safety devices checked and functional. The Contractor's work also includes but is not limited to:
 - a. Calibration and testing of all automatic temperature control devices and building automation systems
 - b. Testing and verification of all interlocks and interfacing between HVAC equipment, controls, systems, subsystems, and other building systems
 - c. Completion of testing, adjusting, and balancing (TAB) work, including the rechecking of 10% of the measurements
- 3 Startup Documentation: Completed startup checklists shall be filled out by the Contractor, and provided to the Commissioning Agent after startup verification of each HVAC system, subsystem or each item of HVAC equipment. Typical checklists may be found at the end of this Specification Section, but shall be used only as a general guideline.
- 4 Notification: The Commissioning Agent shall notify the Owner and Contractor 5 days prior to startup verification and 5 days prior to HVAC functional performance testing.

3.3 FUNCTIONAL PERFORMANCE TESTING

- A. Purpose: Every item of HVAC equipment, all HVAC systems and subsystems, controls, and all related equipment shall be tested and evaluated for conformance to performance data in the contract documents. Testing for the appropriate season shall be performed. The second seasonal test shall follow as soon as weather permits. Heating test shall be performed when outdoor temperature is below 40°F, and summer test shall be performed when outdoor temperature is above 85°F. Included is conformance to:
 - 1 HVAC equipment input and output capacities
 - 2 HVAC systems and subsystems flow and distribution performance
 - 3 Control system performance, accuracy, and adherence to sequences of operation
 - 4 Minimum or part load operations and performance (for VAV systems and central heating and cooling plants)
 - 5 Interface with other equipment and/or systems
- B. HVAC Equipment Testing: Equipment functional performance testing shall not begin until all HVAC equipment and systems have had startup verification by the Contractor and the Commissioning Agent.

- 1 Functional performance test checklists in Appendix B shall be used to document the equipment functional performance tests.
 - 2 Each item of HVAC system equipment will be functional performance tested and the results documented at full load (and under part load conditions where required by the contract documents), (i.e. VAV systems and central heating and cooling plants).
 - 3 Operation under "abnormal and/or emergency conditions" should be simulated for equipment and systems, and all safety equipment and control operations verified. Items on emergency power should be coordinated with generator commissioning.
 - 4 Test methods shall be documented and approved by the Commissioning Agent prior to implementation and shall be covered during the Owner's training as well.
 - 5 No equipment test functions or procedures shall be eliminated from the functional performance test unless approved by the Commissioning Agent and the Rappahannock Community College representative.
- C. HVAC Systems Testing: HVAC systems functional performance testing shall not begin until all HVAC equipment and systems have had startup verification by the Contractor and the Commissioning Agent.
- 1 Functional performance test checklists in Appendix B shall be used to document system or subsystem functional performance tests.
 - 2 The functional performance testing of higher level HVAC systems shall only begin after lower level equipment and subsystems have been acceptably tested and documented. The system interlock and interface testing sequence should depend on the system design, complexity, and other factors.
 - 3 HVAC systems and subsystems shall be tested under full load conditions and under minimum or part load conditions as specified.
 - 4 Actual physical responses shall be observed. Reliance on control signals or other indicators is not acceptable. The DDC control subcontractor team member should bring a laptop computer or handheld for remote manipulation of terminal unit controllers.
 - 5 Control component input and output signals shall be confirmed for correctness under all operating conditions.
 - 6 At the end of the HVAC functional performance test procedures, every mode of each operation of a system, each piece of HVAC equipment, every item in the control sequence description, and every zone or subsystem shall be proven to operate as defined in the project contract documents.
- D. Test Documentation: HVAC functional performance test checklists shall be used to document the results of the HVAC functional performance testing process.

- 1 Testing verification shall be provided by signatures of responsible parties on the HVAC functional performance test checklists and equipment checklists.
 - 2 HVAC functional performance testing shall be performed by the Contractor, by members of the HVAC systems commissioning team as outlined, and approved by the commissioning plan.
 - 3 All members will remain on the HVAC systems commissioning team throughout the entire HVAC functional performance testing procedures. Substitutions will be permitted only by written approval of the Commissioning Agent and Rappahannock Community College representative.
- E. Test Failures: No HVAC system or subsystem shall be accepted until all items of equipment in the HVAC system have approved functional performance test checklists.
- 1 When a functional performance test is not approved, the Contractor shall be directed to provide a written report to the Commissioning Agent listing the deficiencies causing the test failure, and the possible remedies to correct the deficiencies.
 - 2 After all deficiencies have been corrected, the entire functional performance test for the equipment, system, or subsystem shall be repeated.
 - 3 The Commissioning Agent shall continue to monitor the actions to correct the equipment or system deficiencies until an acceptable functional performance test has been accomplished.
- F. Deferred Tests: If any checklist or functional performance test cannot be completed for seasonal reasons, lack of occupancy, or for other reasons, a written report shall be sent by the Contractor to the Commissioning Agent indicating when the test will be scheduled.
- 1 If any checklist or functional performance test cannot be accomplished due to deficiencies outside the scope of the HVAC systems work, the deficiencies shall be resolved and corrected by the appropriate parties before completion of the HVAC commissioning process.

3.4 OPERATOR INSTRUCTION

- A. During System Installation: Schedules and materials for the participation of the operation and maintenance personnel during the installation of the HVAC systems and equipment shall be implemented as per the HVAC Systems Commissioning Plan or as indicated in the Contract Documents by the Contractor.
- 1 Operation and maintenance personnel instruction shall include:
 - a. An instruction agenda with objectives
 - b. Classroom sessions using contract documents (specifications, system drawings), shop drawings, sequence of operations, equipment installation and operation manuals, and audio-visual aids, etc., and as indicated in Section 15000.

- c. "Factory specialist" presentations by representatives approved by the Commissioning Agent.
 - d. Job site visits.
 - e. Sign-in sheets to verify attendance. The commissioning agent is not required to attend.
 - f. Video-taping of all sessions.
- 2 Provide manuals 2 weeks prior to instruction or commissioning.
- B. During Commissioning: The Contractor shall prepare schedules and coordinate the training sessions with the parties involved. The commissioning agent is not required to attend.
 - 1 Equipment and systems maintenance manuals and schedules should be provided along with other information not provided during the installation phase instruction sessions.
- C. Turn-over Instruction: When the HVAC systems are ready to be turned over to the Rappahannock Community College, the Contractor shall schedule a final session for operation and maintenance personnel instruction. The following shall be included:
 - 1 Attendance by the Commissioning Agent, HVAC system designer, installing contractors, major equipment suppliers, and all other interested parties
 - 2 Review of all system and equipment operations
 - 3 Additional hands-on instruction where requested by the Owner or Commissioning Agent
 - 4 A question/answer discussion period

3.5 COMMISSIONING REPORT

- A. The HVAC systems commissioning documentation should be organized into a format similar to the HVAC Systems Commissioning Plan in tabulated 3-ring binder(s). All pages shall be numbered, a table of contents provided, and shall include the following information:
 - 1 Commissioning Plan: Provide a copy of the HVAC Systems Commissioning Plan.
 - 2 TAB Reports: Provide approved testing, adjusting, and balancing (TAB) reports organized by HVAC systems and subsystems for all HVAC systems being commissioned.
 - 3 Drawings: As-built shop drawings of HVAC equipment and systems, sequence of operations, and as-built HVAC system contract documents as modified by change orders shall be provided.

- 4 Startup Checklists: Provide all startup checklists and equipment startup reports, organized by HVAC systems and subsystems.
- 5 Functional Performance Tests: Functional performance test checklists for all HVAC equipment, systems, subsystems, interlocks, and system interfaces shall be provided and be organized by HVAC systems and subsystems. Include results of failed tests and corrective action taken.
- 6 Operation and Maintenance Manuals: Copies of approved operation and maintenance manuals specified in the HVAC systems contract documents and/or in the HVAC Systems Commissioning Plan organized by HVAC systems and subsystems shall be included.
- 7 Operator Instruction: Copies of construction agendas, attendance sheets and video-tapes organized by HVAC systems and subsystems. Label video-tapes by project, subject and date.
- 8 Warranties: Copies of all warranties and system guarantees specified in the contract documents.

3.6 ACCEPTANCE

- A. Documents to Owner: The Contractor and the Owner's Commissioning Agent (Engineer) shall be responsible for maintaining the HVAC systems commissioning documentation until final acceptance of the project. All checklists required by this Section shall become part of the commissioning documentation. The commissioning documentation shall be kept current and shall be available for inspection at all times at the jobsite. At the time of acceptance of the project, the Contractor shall furnish copies of the commissioning documentation to the Owner's Commissioning Agent (Engineer) for final approval and submission to Norfolk Public Schools.
- B. Warranties: All equipment and system guarantees and warranties specified in the HVAC systems contract documents shall be furnished to the Owner by the parties involved.
- C. Record Drawings: During construction, the Contractor shall keep an accurate record of deviations between the work as shown on the contract drawings and that which is actually installed. He shall secure a set of blue line prints of the mechanical drawings for this purpose, and note changes thereon in red ink, in a neat and accurate manner, thus making a complete record of all changes and revisions in the original design which exist in the completed work. The cost of furnishing above prints and preparing these record drawings shall be included in the contract price by the Mechanical Contractor. When revisions have been shown on these prints to indicate the work as installed, the prints shall be delivered to the commissioning agent, before final payment.

3.7 APPENDIX

Attached.

END OF SECTION

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

Pre-commissioning checklist - Piping

For [_____] Piping System

Checklist Item	Q	M	E	T	C	O
Installation						
a. Piping complete.	___	___	X	___	X	___
b. As-built shop drawings submitted	___	___	X	___	X	___
c. Piping flushed and cleaned.	___	___	X	___	X	___
d. Strainers cleaned.	___	___	X	___	X	___
e. Valves installed as required.	___	___	X	___	X	___
f. Piping insulated as required	___	___	X	___	X	___
g. Thermometers and gauges installed as required.	___	___	X	___	X	___
h. Verify operation of valves.	___	___	X	___	___	___
i. Air vents installed as specified.	___	___	X	X	X	___
j. Flexible connectors installed as specified	___	___	X	X	X	___
k. Verify that piping has been labeled and valves identified as specified.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)						
a. Hydrostatic test complete.	___	___	X	___	X	___
b. TAB operation complete	___	___	X	___	___	___

Pre-commissioning Checklist - Ductwork

For Air Handler: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Ductwork complete.	___	___	X	___	X	___
b. As-built shop drawings submitted.	___	___	X	___	X	___
c. Ductwork leak test complete.	___	___	X	___	X	___
NOTE: The first bracketed item d will be used for Army projects, the second for Air Force projects.						
d. Fire dampers and access doors installed as required.	___	___	X	___	X	___
e. Ductwork insulated as required.	___	___	X	___	X	___
f. Thermometers and gauges installed as required.	___	___	___	___	___	___
g. Verify open/closed status of dampers.	___	___	X	___	X	___
h. Flexible connectors installed as specified	___	___	X	___	X	___
Testing, Adjusting, and Balancing (TAB)						
a. TAB operation complete.	___	___	X	___	X	___

Pre-commissioning Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Vibration isolation devices installed.	___	___	X	X	X	___
b. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
c. Casing undamaged.	___	___	X	X	X	___
d. Insulation undamaged.	___	___	X	X	X	___
e. Condensate drainage is unobstructed. (Visually verify drainage by pouring a cup of water into drain pan.)	___	___	X	X	X	___
f. Fan belt adjusted.	___	___	X	___	X	___
g. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___
Electrical						
a. Power available to unit disconnect/VFD's	___	___	___	X	X	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___
d. Verify that power disconnect/VFD is located within sight of the unit it controls.	___	___	___	X	___	___
Coils						
a. Chilled water piping properly connected.	___	___	X	X	X	___
b. Chilled water piping pressure tested.	___	___	X	X	X	___
c. Hot water piping properly connected.	___	___	X	X	X	___
d. Hot water piping pressure tested.	___	___	X	X	X	___
e. Air vents installed on water coils as specified.	___	___	X	X	X	___
f. Any damage to coil fins has been repaired.	___	___	X	___	X	___

Controls

a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___
e. Verify proper location, installation and calibration of duct static pressure sensor.	___	___	X	___	___	___
f. Fan air volume controller operable.	___	___	X	___	___	___
g. Air handler controls system operational	___	___	X	___	___	___

Testing, Adjusting, and Balancing (TAB)

a. Construction filters removed and replaced.	___	___	X	___	___	___
b. TAB report submitted.	___	___	X	___	X	___
c. TAB results within +10%/-5% of cfm shown on drawings						
d. TAB results for outside air intake within +10%/-5% of both the minimum and maximum cfms shown on drawings.	___	___	X	___	X	___

Pre-commissioning Checklist - VAV Terminal

For VAV Terminal: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. VAV terminal in place.	___	___	X	X	X	___
b. VAV terminal ducted.	___	___	X	X	X	___
c. VAV terminal connected to controls.	___	___	X	X	___	___
d. Reheat coil connected to hot water pipe.	___	___	X	___	X	___
e. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___
Controls						
a. Reheat VAV terminal controls set.	___	___	X	X	___	___
b. Reheat terminal/coil controls verified.	___	___	X	X	___	___
Testing, Adjusting, and Balancing (TAB)						
a. Verify terminal maximum airflow set.	___	___	X	___	___	___
b. Verify terminal minimum airflow set.	___	___	X	___	___	___
c. TAB operation complete.	___	___	X	___	X	___

Pre-commissioning Checklist - DX Air Cooled Condensing Unit

For Condensing Unit: []

Checklist Item	Q	M	E	T	C	O
Installation	___	___	X	X	X	___
a. Refrigerant pipe leak tested.	___	___	X	X	X	___
b. Refrigerant pipe evacuated and charged in accordance with manufacturer's instructions.	___	___	X	X	X	___
c. Check condenser fans for proper rotation.	___	___	X	___	X	___
d. Any damage to coil fins has been repaired.	___	___	X	___	X	___
e. Manufacturer's required maintenance/operational clearance provided.	___	___	X	X	X	___
Electrical						
a. Power available to unit disconnect.	___	___	___	X	X	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Verify that power disconnect is located within sight of the unit it controls	___	___	___	X	___	___
Controls						
a. Unit safety/protection devices tested.	___	___	X	X	___	___
b. Control system and interlocks installed.	___	___	X	X	___	___
c. Control system and interlocks operational.	___	___	X	X	___	___

Pre-commissioning Checklist - Pumps

For Pump: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Pumps grouted in place.	___	___	X	X	X	___
b. Pump vibration isolation devices functional.	___	___	X	X	X	___
c. Pump/motor coupling alignment verified.	___	___	X	X	X	___
d. Piping system installed.	___	___	X	X	X	___
e. Piping system pressure tested.	___	___	X	X	X	___
f. Pump not leaking.	___	___	X	X	X	___
g. Field assembled couplings aligned to meet manufacturer's prescribed tolerances.	___	___	X	X	X	___
Electrical						
a. Power available to pump disconnect or VFD.	___	___	___	X	X	___
b. Pump rotation verified.	___	___	___	X	X	___
c. Control system interlocks functional.	___	___	___	X	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
Testing, Adjusting, and Balancing (TAB)						
a. Pressure/temperature gauges installed.	___	___	X	___	X	___
b. Piping system cleaned.	___	___	X	X	X	___
c. Chemical water treatment complete.	___	___	X	X	X	___
d. Water balance complete.	___	___	X	___	X	___
e. Water balance with design maximum flow.	___	___	X	___	X	___
f. TAB Report submitted.	___	___	X	___	X	___

Pre-commissioning Checklist - Packaged Air Cooled Chiller

For Chiller: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Chiller properly piped.	___	___	X	___	___	___
b. Chilled water pipe leak tested.	___	___	X	X	X	___
c. Verify that refrigerant used complies with specified requirements.	___	___	X	X	X	___
d. Any damage to coil fins has been repaired.	___	___	X	___	X	___
e. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___
Electrical						
a. Power available to unit disconnect.	___	___	___	X	___	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Separate power is supplied to electric heating tape.	___	___	___	X	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
Controls						
a. Factory startup and checkout complete.	___	___	X	X	___	___
b. Chiller safety/protection devices tested.	___	___	X	X	___	___
c. Chilled water flow switch installed.	___	___	X	X	___	___
d. Chilled water flow switch tested.	___	___	X	X	___	___
e. Chilled water pump interlock installed.	___	___	X	X	X	___
f. Chilled water pump interlock tested.	___	___	___	X	___	___

Pre-commissioning Checklist - Hot Water Boiler

For Boiler: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Boiler flue installed.	___	___	X	___	___	___
b. Boiler hot water piping installed.	___	___	X	___	___	___
c. Boiler hot water piping tested.	___	___	X	X	___	___
d. Boiler makeup water piping installed.	___	___	X	___	___	___
e. Boiler gas piping installed.	___	___	X	X	X	___
f. Boiler gas piping tested.	___	___	X	X	X	___
g. Manufacturer's required maintenance clearance provided.	___	___	X	___	___	___
Startup						
a. Boiler system cleaned and filled with treated water.	___	___	X	___	___	___
b. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre and post purge, have been tested.	___	___	___	X	___	___
c. Verify that PRV rating conforms to boiler rating.	___	___	___	X	___	___
d. Boiler water treatment system functional.	___	___	X	X	___	___
e. Boiler startup and checkout complete.	___	___	X	X	___	___
Electrical						
a. Verify that power disconnect is located within sight of the unit served.	___	___	___	X	___	___
Controls						
a. Hot water pump interlock installed.	___	___	___	X	___	___
b. Hot water pump interlock tested.	___	___	___	X	___	___
c. Hot water heating system balanced.	___	___	X	X	___	___

d. Hot water heating controls operational.

___ ___ X X ___ ___

Pre-commissioning Checklist - Unit Heater or Hot Water Convactor

For Unit: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Hot water piping properly connected.	___	___	X	___	___	___
b. Hot water piping pressure tested.	___	___	X	___	___	___
c. Air vent installed on hot water coil with shutoff valve as specified.	___	___	X	X	X	___
d. Any damage to coil fins has been repaired.	___	___	X	___	X	___
e. Manufacturer's required maintenance/operational clearance provided.	___	___	X	X	X	___
Electrical						
a. Power available to unit disconnect.	___	___	___	X	___	___
b. Proper motor rotation verified.	___	___	___	X	X	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
d. Power available to electric heating coil.	___	___	___	X	___	___
Controls						
a. Control valves properly installed.	___	___	X	___	___	___
b. Control valves operable.	___	___	X	X	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)						
a. TAB Report submitted.	___	___	X	___	X	___

Pre-commissioning Checklist - Exhaust/Supply Fan

For Exhaust/Supply Fan: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. Fan belt adjusted.	___	___	X	___	X	___
Electrical						
a. Power available to fan disconnect	___	___	___	X	___	___
b. Proper motor rotation verified.	___	___	___	___	X	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
Controls						
a. Control interlocks properly installed.	___	___	___	X	___	___
b. Control interlocks operable.	___	___	___	X	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)						
a. TAB results +10%/-5% to cfm shown on drawings	___	___	X	___	X	___
b. TAB Report submitted.	___	___	X	___	X	___

Pre-commissioning Checklist - HVAC System Controls

For HVAC System: []

Checklist Item	Q	M	E	T	C	O
Installation						
a. As-built shop drawings submitted.	___	___	X	X	___	___
b. Layout of control panel matches drawings.	___	___	X	X	___	___
c. Framed instructions mounted in or near control panel.	___	___	X	X	___	___
d. Components properly labeled (on inside and outside of panel).	___	___	X	X	___	___
e. Control components piped and/or wired to each labeled terminal strip.	___	___	X	X	___	___
f. EMCS connection made to each labeled terminal strip as shown.	___	___	X	X	___	___
g. Control wiring labeled at all terminations, splices, and junctions.	___	___	X	X	___	___
h. Shielded wiring used on electronic sensors.	___	___	X	X	___	___
Main Power						
a. 110 volt AC power available to panel.	___	___	___	X	___	___
Testing, Adjusting, and Balancing						
a. Testing, Adjusting, and Balancing Report submitted.	___	___	X	___	___	___

APPENDIX B

FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

Functional Performance Test Checklist - Pumps

For Pump: [_____]

Prior to performing this checklist, ensure that for closed loop systems, system is pressurized and the make-up water system is operational or, for open loop systems, that the sumps are filled to the proper level.

1. Activate pump start using control system commands (all possible combination, on/auto, etc.).

ON _____ AUTO _____ OFF _____

a. Verify pressure drop across strainer:

Strainer inlet pressure _____ psig
Strainer outlet pressure _____ psig

b. Verify pump inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, pump design conditions, and pump manufacturer's performance.

	DESIGN	SYSTEM TEST	ACTUAL
Pump inlet pressure (psig)	_____	_____	_____
Pump outlet pressure (psig)	_____	_____	_____

c. Operate pump at shutoff and at 100 percent of designed flow when all components are in full flow. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure (psig)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (gpm)	_____	_____

d. Operate pump at shutoff and at minimum flow or when all components are in full by-pass. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure (psig)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (gpm)	_____	_____

2. Verify motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions.

a. Full flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____

Voltage	_____	_____
Voltage	_____	_____
Voltage to ground	_____	_____

b. Minimum flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

3. Unusual vibration, noise, etc.

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - VAV Terminals

The Contracting officer will select VAV terminals to be spot-checked during the functional performance test. The number of terminals shall not exceed [2] [10] [10 percent].

1. Functional Performance Test: Contractor shall demonstrate operation of selected VAV boxes as per specifications including the following:

- a. Cooling with reheat VAV boxes:

- (1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to 5 degrees F above ambient and measure maximum air flow. Turn thermostat to 5 degrees F below ambient and measure minimum air flow.

Maximum flow [] cfm

Minimum flow [] cfm

- (2) Check damper maximum/minimum flow settings.

Maximum flow setting [] cfm

Minimum flow setting [] cfm

Reheat coil operation range (full open to full closed) _____

- b. Fan powered VAV boxes:

- (1) Verify VAV box response to sensor call for heating via set point adjustment. Changes to be cooling setpoint to heating set point and return to cooling set point. _____. Verify cooling damper closes to minimum position, blower fan energizes according to sequence of operation, and upon further drop in space temperature, heating coil activation and deactivation. _____

- (2) Check primary air damper maximum/minimum flow settings.

Maximum flow setting [] cfm

Minimum flow setting [] cfm

- (3) Check blower fan flow. [] cfm

Maximum flow setting [] cfm

Minimum flow setting [] cfm

- (4) Verify free operation of fan backdraft damper (insure no primary air is being discharged through the recirculated air register).

- (5) Verify that no recirculated air is being induced when box is in full cooling.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: []

Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. The following shall be verified when the [supply fan operating] [supply and return fans operating] mode is initiated:

- (1) All dampers in normal position [and fan inlet vanes modulate to maintain the required static pressure]. _____
- (2) All valves in normal position. _____
- (3) System safeties allow start if safety conditions are met. _____
- (4) VAV fan controller shall "soft-start" fan. _____
- (5) Modulate all VAV boxes to minimum air flow and verify that the static pressure does not exceed the design static pressure Class shown.

b. Occupied mode of operation - economizer de-energized.

- (1) Outside air damper at minimum position. _____
- (2) Return air damper open. _____
- (3) Relief air damper at modulating. _____
- (4) Chilled water control valve modulating to maintain leaving air temperature set point.

- (5) Fan VAV controller receiving signal from duct static pressure sensor and modulating fan to maintain supply duct static pressure set point.

c. Occupied mode of operation - economizer energized.

- (1) Outside air damper modulated to maintain mixed air temperature set point.

- (2) Relief air damper modulates with outside air damper according to sequence of operation.

- (3) Chilled water control valve modulating to maintain leaving air temperature set point.

(4) Hot water control valve modulating to maintain leaving air temperature set point.

(5) Fan VAV controller receiving signal from duct static pressure sensor and modulating fan to maintain supply duct static pressure set point.

d. Unoccupied mode of operation

(1) All dampers in normal position. _____

(2) Verify low limit space temperature is maintained as specified in sequence of operation.

e. The following shall be verified when the [supply fan off] [supply and return fans off] mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) Fan de-energizes. _____

f. Verify the chilled water coil control valve operation by setting all VAV's to maximum and minimum cooling.

	Max cooling	Min cooling
Supply air volume (_____ cfm)	_____	_____
Supply air temp. (_____ degrees F)	_____	_____

g. Verify safety shut down initiated by smoke detectors. _____

h. Verify safety shut down initiated by low temperature protection thermostat.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller: [_____]

1. Functional Performance Test: Contractor shall demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows.
 - a. Start chilled water pump and establish chilled water flow. Verify chiller-chilled water proof-of-flow switch operation. _____
 - b. Verify control system energizes chiller start sequence. _____
 - c. Verify chiller senses chilled water temperature above set point and control system activates chiller start. _____
 - d. Verify functioning of "soft start" sequence. _____
 - e. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed.

 - f. Restart air handling equipment one minute after chiller shut down. Verify chiller restart sequence.

2. Verify chiller inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Chiller inlet pressure (psig)	_____	_____	_____
Chiller outlet pressure (psig)	_____	_____	_____

3. Verify chiller amperage each phase and voltage phase-to-phase and phase-to-ground.

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

4. Record the following information:

Ambient dry bulb temperature _____ degrees F
Ambient wet bulb temperature _____ degrees F
Entering chilled water temperature _____ degrees F
Leaving chilled water temperature _____ degrees F

5. Unusual vibration, noise, etc.

-
6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - Air Cooled Condensing Unit

For Condensing Unit: []

1. Functional Performance Test: Contractor shall demonstrate operation of refrigeration system as per specifications including the following: Start building air handler to provide load for condensing unit. Activate controls system start sequence as follows.

- a. Start air handling unit. Verify control system energizes condensing unit start sequence.

- b. Shut off air handling equipment to verify condensing unit de-energizes.

- c. Restart air handling equipment one minute after condensing unit shut down. Verify condensing unit restart sequence.

2. Verify condensing unit amperage each phase and voltage phase to phase and phase to ground.

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

3. Record the following information:

Ambient wet bulb temperature _____ degrees C

Discharge pressure _____ kPa gauge

Ambient dry bulb temperature _____ degrees F

Ambient wet bulb temperature _____ degrees F

Suction pressure _____ psig

Discharge pressure _____ psig

4. Unusual vibration, noise, etc.

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - Hot Water Boiler

For Boiler: []

1. Functional Performance Test: Contractor shall demonstrate operation of hot water system as per specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.
 - a. Start hot water pump and establish hot water flow. Verify boiler hot water proof-of-flow switch operation. _____
 - b. Verify control system energizes boiler start sequence. _____
 - c. Verify boiler senses hot water temperature below set point and control system activates boiler start. _____
 - d. Shut off building heating equipment to remove load on hot water system. Verify boiler shutdown sequence is initiated and accomplished after load is removed.

2. Verify boiler inlet/outlet pressure reading, compare to Test and Balance (TAB) Report, boiler design conditions, and boiler manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Boiler inlet pressure (psig)	_____	_____	_____
Boiler outlet pressure (psig)	_____	_____	_____
Boiler flow rate (gpm)	_____	_____	_____
Flue-gas temperature at boiler outlet	_____	_____	_____
Percent carbon dioxide in flue-gas	_____	_____	_____
Draft at boiler flue-gas exit	_____	_____	_____
Draft or pressure in furnace	_____	_____	_____
Fuel type	_____	_____	_____

3. Record the following information:

Ambient temperature	_____	degrees F
Entering hot water temperature	_____	degrees F
Leaving hot water temperature	_____	degrees F

4. Verify temperatures in item 3 are in accordance with the reset schedule.

5. Verify proper operation of boiler safeties. _____

6. Unusual vibration, noise, etc.

7. Visually check refractory for cracks or spalling and refractory and tubes for flame impingement.

8. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - Unit Heaters/Hot Water Convectors

1. Functional Performance Test: Contractor shall demonstrate operation of selected unit heaters as per specifications including the following:
 - a. Verify unit heater response to room temperature set point adjustment. Changes to be heating set point to heating set point minus 10 degrees and return to heating set point.

 - b. Check blower fan speed. _____rpm
 - c. Check heating mode inlet air temperature. Check heating mode inlet air temperature. _____degrees F
 - d. Check heating mode outlet air temperature. Check heating mode outlet air temperature. _____degrees F
2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - HVAC Controls

For HVAC System: [_____]

The Commissioning Agent will select HVAC control systems to undergo functional performance testing. The number of systems shall not exceed 10 percent.

1. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the following tests:
 - a. Verify that controller is maintaining the set point by manually measuring the controlled variable with a thermometer, sling psychrometer, inclined manometer, etc.
 - b. Verify sensor/controller combination by manually measuring the controlled medium. Take readings from control panel display and compare readings taken manually. Record all readings.

Sensor _____
Manual measurement _____
Panel reading value _____

- c. Verify system stability by changing the controller set point as follows:
 - (1) Air temperature - 10 degrees F
 - (2) Water temperature - 10 degrees F
 - (3) Static pressure - 10 percent of set point
 - (4) Relative humidity - percent (RH)

The control system shall be observed for 10 minutes after the change in set point. Instability or excessive hunting will be unacceptable.

- d. Verify interlock with other HVAC controls.
 - e. Verify interlock with fire alarm control panel.
 - f. Verify interlock with EMCS.
 - g. Change controller set point 10 percent with EMCS and verify correct response.
2. Verify that operation of control system conforms to that specified in the sequence of operation.
 3. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Owner's Commissioning Agent (Engineer)

Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System: []

1. Functional Performance Test: Contractor shall demonstrate operation of energy recovery system as per specifications including the following: Start equipment to provide energy source for recovery system.
 - a. Verify energy source is providing recoverable energy. _____
 - b. Verify recovery system senses available energy and activates. _____
 - c. Verify that recovery system deactivates when recoverable energy is no longer available. _____
2. Verify recovery system inlet/outlet readings, compare to design conditions and manufacturer's performance data.

	Design	Actual
Primary loop inlet temp (degrees F)	_____	_____
Primary loop outlet temp (degrees F)	_____	_____
Primary loop flow rate	_____	_____
Secondary loop inlet temp (degrees F)	_____	_____
Secondary loop outlet temp (degrees F)	_____	_____
Energy recovered BTU's)	_____	_____

3. Check and report unusual vibration, noise, etc.

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing, Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Owner's Commissioning Agent (Engineer) _____

END OF COMMISSIONING OF HVAC SYSTEMS

SECTION 15970

DIRECT DIGITAL CONTROL SYSTEM

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. The General Provisions of the Contract, including General and Supplementary Conditions apply to the work specified in this Section.

1.2 WORK INCLUDED

- A. DDC system shall be "Aero Automated Logic Controls", contact: Jeff Smidler (804) 747-9528.
- B. Provide a Building Control System (BCS) incorporating Direct Digital Control (DDC), energy management, and equipment monitoring and control, consisting of the following elements:
 - 1. Microcomputer based Digital Control Panel (DCP) interfacing directly with sensors, actuators and environmental delivery systems (i.e., HVAC units, boilers, chillers, etc.).
 - 2. Electric controls and mechanical devices for all items indicated on drawings and described hereinafter including dampers, valves and panels.
 - 3. Where more than DCP is required, a two-wire peer communication network to allow data exchange from DCP to DCP at a minimum rate per second of one megabit.
 - 4. Points required by either the sequence or the diagrams shall be included even if not indicated in both places.
- C. The BAS/ATC contractor shall be responsible for fully interfacing to the existing facility work station(s), (located remote to the building) at no additional cost to the owner. This includes software updates for a minimum of one desktop computer and one laptop computer.
- D. The contractor shall provide a logical presentation of graphical displays with the following higher hierarchical levels:
 - 1. Overall site plan: Provide a graphic depicting an overall site plan showing all buildings being monitored. Each building shall contain a transfer, which will allow the operator to penetrate each respective building.
 - 2. Floor plan graphic: Provide a graphic depicting each floor or zone contained in that building. Each screen shall contain transfers to other floors or zones, as well as backed to the overall site plan.
 - 3. Mechanical Systems: Provide a graphical schematic for each mechanical system shown on the drawings. Each sensed or controlled physical point shall be dynamically displayed. Each screen shall contain transfers to building floor plans or zones, as well as backed to the overall site plan.

- E. Submittals, data entry, electrical installation, programming, start up, test and validation, instruction of Owner's representative on maintenance and operation, as built documentation, and system warranty.
- F. Laptop Computer: Provide 2.0 GHZ, USB, Ethernet and RS232 port, 17" display, CD RW x 24 drive, 60 GB hard drive, 2.0 GB ram internal 56K modem, internet ready, wireless capable, and printer port. Provide with vendors full software package for maintenance and system control from remote locations.
- G. Front End Computer: Provide non-integrated 2.0 GHZ, Ethernet port, RS 232 port, printer port, CD RW x 24 drive, 60 GB hard drive, 2.0 GB ram internal 56K modem, (2) USB ports, internet ready, wireless capable, 17" LCD monitor, mouse, keyboard, (2) speaker audio. Provide manufacturer's latest front end software package, update any existing school DDC interfaces to new software version.

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 15060 - Pipe and Pipe Fittings: Installation of control valves, temperature sensor wells, gauge taps.
- B. Section 16220 - Conductors: Installation and connection of all power wiring. Power wiring shall be defined as follows:
 - 1. Wiring of power feeds through all disconnects and starters to electric motors.
 - 2. Wiring of any remote start/stop switches not furnished by the BCS Contractor.

1.4 QUALITY ASSURANCE

- A. The system shall be installed by competent mechanics, regularly employed by the BSC manufacturer or an approved authorized agent with full responsibility for proper operation of the BSC including debugging and proper calibration of each component in the entire system.
- B. Major DDC components such as standalone control units shall be directly manufactured by the approved manufacturer and may not be the product of another manufacturer resold under the approved manufacturer's name.
- C. Supplier shall have an in-place support facility within 30 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- D. Codes and Approvals:
 - 1. The complete BCS installation shall be in strict accordance to the national and local electrical codes and the electrical section of these specifications. All devices designed for or used in line voltage applications shall be UL listed.
 - 2. All microprocessor based devices shall be UL916 listed.
 - 3. All electronic equipment shall conform to the requirements of FCC regulation Class B Part 15, Section 23 governing radio frequency electromagnetic interference and be so labeled.

- E. All system components are to be designed and built to be fault tolerant.
 - 1. Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at +3 hertz variation in line frequency.
 - 2. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be a.c. coupled or equivalent so that any single device failure will not disrupt or halt bus communication.

1.5 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 15000 Mechanical General Provisions.
- B. Identification of devices on shop drawings shall be the same as those used in the Contract Documents. Control submittals shall contain the following:
 - 1. Schematic of each item of mechanical equipment, locating each control component on its respective unit with proper termination point identifiers (including legend). One Schematic shall be included for each air handling system.
 - 2. Each schematic shall also have a corresponding wiring diagram in ladder form. Each schematic shall have an equipment list detailing all hardware components used. The list shall include:
 - a. Schematic Control Symbol
 - b. Quantity
 - c. Manufacture's Part Number
 - d. Tech Sheet Reference (include in submittal)
 - e. Description of Part
 - 3. Data sheets for each hardware component.
 - 4. Valve and well and tap schedules showing size, configuration, capacity and location of all equipment.
 - 5. Each DCP shall be detailed in the submittal to identify termination boards within each panel and terminal of their respective fields points. Each termination point shall define the point name and point description by each terminal within the DCP. Point names and descriptors shall be constant throughout the submittal on the schematics, wiring diagrams, equipment list, etc.
 - 6. A report shall be included in the submittal to include every point:
 - a. Point Name
 - b. Point Type (analog, digital, etc.)
 - c. Point Descriptor
 - d. Physical Address (enclose legend)
 - e. Alarm (yes or no)
 - f. Display Alarm (yes or no) - message displayed for each alarm
 - g. High Limit
 - h. Low Limit
 - i. Totalized (yes or no)
 - j. Hours or Minutes Totalized
 - k. Engineering Units of Point

7. Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all fan systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total). All text shall be approved prior to data entry.
 8. Software design data including:
 - a. Flowchart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
 - b. English language sequence of operation relating to all flowchart functions.
 9. Laptop computer and field maintenance software.
- C. Operation and Maintenance Manual
1. CD of program including graphics
 2. DDC software
 3. DDC hardware (including terminal sensors)
 4. Valves
 5. Dampers

PART 2 - PRODUCTS

2.1 COMPUTERS AND SOFTWARE

- A. Refer to paragraphs 1.2 E. and 1.2 F.

2.2 MATERIALS

- A. All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use. It is the intent to use the most current manufacture of the sources identified such as Trane Tracer Revision 14.0 and Landis & Gyr Powers 600 Series Version 12.2. No other manufacturers are acceptable. Exceptions to the specifications will qualify the bid as unacceptable.

2.3 GENERAL

- A. The Building Automation System shall include but not be limited to the following components.
1. The Operator Interface shall consist of hardware and software that allows full user monitoring and adjustment of system parameters.
 2. System Application Controllers shall manage the Energy and Building Management capabilities of the automation system and have capability to be adapted to facilitate remote communications and central monitoring.
 3. Custom Application Controllers with distributed custom programming capability shall provide control for nonstandard control sequences.
 4. The Data Communications capability shall allow data to be shared between the various controllers in the architecture.

5. The system software shall include system software for global application functions, application software for distributed controllers, and operator interface software.
 6. End devices such as sensors, actuators, dampers, valves, and relays.
 7. Manufacturer's latest software for full access and control on a minimum of one laptop and one desktop computer.
 8. (1) maintenance laptop, refer to 1.2.
 9. (1) desktop computer, refer to 1.2.
- B. The failure of any single component shall not interrupt the control strategies of other operational devices. System expansion shall be through the addition of end devices, controllers, and other devices described in this specification.

2.4 BUILDING CONTROL PANEL MODEM ETHERNET INTERFACE

- A. System architecture shall provide separate ports for Ethernet, and portable laptop. Manual switching from Ethernet, to portable laptop on a single port is not acceptable.

2.5 SYSTEM APPLICATION CONTROLLERS (SAC)

- A. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based System Application Controllers to manage the global strategies described in Application software section.
- B. The System Application Controller shall have ample memory to support its operating system, database, and programming requirements.
- C. The operating system of the System Application Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
- D. Data shall automatically be shared between System Application Controllers when they are networked together.
- E. The database and custom programming routines of remote System Application Controllers shall be editable from a single operator station.
- F. The System Applications Controllers shall have the capability to be remotely monitored over telephone modem. Additional capabilities shall include automatically dialing out alarms, gathering alarms, reports and logs, programming and downloading databases.
- G. The controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
1. Assume a predetermined failure mode.
 2. Emit an alarm.
 3. Display card failure identification.

2.6 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient memory to handle its operating system, database and programming requirements.
- B. The Application Specific Controller shall be pre-programmed, tested and factory mounted on the mechanical equipment to ensure reliability.
 - 1. Where factory mounting is not possible, the controllers shall be factory programmed and tested prior to shipment to the jobsite. The controllers shall be clearly labeled as to controller type, where it is to be installed, and software address (if applicable). The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.
- C. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.
- D. The controller shall have a display and keypad for local interface with the mechanical equipment. Display and keypad are not required for fan coil units and blower coil air handlers.
 - 1. A keypad shall be provided for interrogating and editing data and the display shall be LCD.
 - 2. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
 - 3. A keypad and display shall be mounted on the unit it is controlling.
 - 4. A portable service tool is acceptable, but must be permanently mounted at the location specified for the keypad and display. No exceptions will be permitted.
- E. The hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at -40F to 155F.
 - 2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32F to 120F.

2.7 CUSTOM APPLICATION CONTROLLERS (CAC)

- A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient memory to support its operating system, database, and programming requirements.
- B. All programming required for operation shall be memory resident and shall be retained in permanent memory. Battery backup for a minimum of 72 hours is also permissible.
- C. The Custom Application Controller shall be configured such that the Operator Interface can be plugged directly into it or within sight for programming, editing, and other operator functions.

- D. The controller shall have a display and keypad for local interface with the mechanical equipment.
 - 1. Keypad shall be provided for interrogating and editing data and the display shall be LCD.
 - 2. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
 - 3. A portable service tool is acceptable but must be permanently mounted at the location specified for the keypad and display. No exceptions will be permitted.
- E. Controller hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at -40F to 155F.
 - 2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32F to 120F.

2.8 INPUT/OUTPUT INTERFACE

- A. Hardwired inputs and outputs may tie into the system through System Application, Custom Application, or Application Specific Controllers. Slave devices are also acceptable. Any critical points requiring immediate reaction shall be tied directly into the controller hosting the control software algorithm for the critical function.
- B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of 12MA at 12VDC to be compatible with commonly available control devices.
 - 1. All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.
- C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.
- D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices.
- E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 milliampere signal as required to provide proper control of the output device as indicated on the points schedule.

2.9 AUXILIARY CONTROL DEVICES

- A. Thermostats:
 - 1. Electric thermostats for heating and ventilation control applications shall be line or low voltage type suitable for the application with SPDT switch action for on-off heating/cooling control or modulating type as required. Low voltage type shall have adjustable heat anticipation. Ratings shall be adequate for the applied load.

Thermostats shall have exposed setpoint and temperature indication, cover, and Allen head screws. Provide thermostat for cabinet unit heaters with concealed set point and temperature indication, cover, and Allen head screws.

- a. Thermostat Guards: Provide clear lockable thermostat guards in all publicly utilized spaces (i.e. corridors, cafeterias, gymnasiums). Provide metal wire guards in gymnasiums.

B. Insertion Freeze Protection Switch (Freezestat):

1. Electric switch shall be capillary type. Provide special purpose insertion thermostats with flexible elements a minimum of 20 feet in length for coil face areas up to 40 square feet. Switch contacts shall be rated for motor starter circuit voltage being interrupted. Switch shall be equipped with auxiliary set of contacts for input of switch status to digital controller. Provide additional elements or longer elements for larger coils at the rate of 1 foot length of element per 4 square feet of coil. Serpentine capillary in a plane perpendicular to the air flow to uniformly sense the entire airflow. A freezing condition at 18 inch increments along the sensing element shall activate the thermostatic switch. Switch shall require manual reset after activation.

C. Duct Smoke Detectors:

1. Duct smoke detectors shall be provided and powered under Section 16721. Controls contractor shall mount and wire to fan circuit.

D. Valves:

1. All valves shall be cage guided and provided with equal percentage modulating plugs, renewable composition disc especially compounded for water service to assure tight seating and operators equipped with molded rubber diaphragm. The plug shall be designed to provide an equal percentage relationship between valve lift and valve flow at a constant pressure drop. Three-way valves shall be equipped with modulating type plug assemblies, and shall have one seat machined integral with the body and the other with the three-way valve end. Valves shall be sized as shown on the drawings or as required to guarantee sufficient size to meet the cooling or heating requirements with specified pressure drops. Water valves shall be sized for 3 psi pressure drop where not otherwise indicated on drawings by Cv value. Valves 2 inches and smaller shall have screwed connections and valves 2-1/2 inches and larger shall have flanged connections. Control valve actuators shall be of the electric type.

E. Dampers:

1. Dampers are provided with equipment where indicated. Controls contractor is responsible for providing opposed blade control dampers mounted in ductwork.
2. Damper actuators shall be electrically operated having reversible proportional shaft output with spring return in the event of power interruptions. Operator rods with a bracket arrangement located outside the air stream whenever possible. All damper actuators shall be of the sufficient size to operate their respective dampers effectively. Where two or more dampers are to be operated by the same controlling

instrument, or where the damper is to operate in sequence with another control device, each damper actuator shall be furnished with spring return.

F. Actuators:

1. All automatically controlled devices, unless specified otherwise elsewhere, shall be provided with electric actuators sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close-off. Where two or more actuators are to be operated in sequence with each other, sequencing shall be by spring range, or by digital sequencing with separate analog outputs, as specified in the sequence of operation.

G. Transformers:

1. Provide step-down transformers where control equipment operates at lower than line circuit voltage. Transformers serving individual heating, ventilating, and air conditioning units shall be fed from the nearest distribution panel board or motor control center, using circuits provided for the purpose. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Size transformers so that 80 percent of the rated capacity equals the connected load.

H. Control Relays:

1. Shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, and enclosed in a dust proof enclosure. Relays shall be socket type, plug into a fixed base, and be replaceable without need of tools or removing wiring.

I. Transmitters:

1. Electronic temperature transmitters shall be RTD type, nickel wound with 0.1% accuracy over the full scale. Elements shall be for duct, outside, or insertion with separable well as required. No calibration or adjustments shall be required at the element location.

J. Sensors:

1. Outside Air Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Outside air temperature sensors shall be RTD type with a minimum range of -20 degrees F to 120 degrees F. The sensor shall provide a 4-20 ma output with adjustable span of zero. Thermistors may not be used for outside air temperature sensing. Provide element with sun shade to minimize solar effects. Mount sun shade at least 3 inches from building outside wall. Sun shade shall not inhibit the flow of ambient air across the sensing element. Shade shall also protect sensing element from snow, ice, and rain.
2. Space Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Room temperature sensors shall be RTD type with a minimum range of 50 degrees F to 100 degrees F. Use 4-20 ma sensors where necessary to meet accuracy requirements. Thermistor-type sensors may be 1,000, 10,000, or 100,000 ohm. Each room temperature sensor shall contain an integral push button for

occupant initiated events such as night setback override. Sensor shall also contain an override cancel pushbutton. Sensor override capability shall be activated or deactivated at the maintenance office graphic work station as required by the owner. Mechanical timers are not acceptable.

- a. Thermostat Guards: Provide clear lockable thermostat guards in all publicly utilized spaces (i.e. corridors, cafeterias). Provide metal wire guards in gymnasiums.
3. Immersion Pipe Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Immersion temperature sensors shall be RTD type with a range selected for the application. Immersion temperature sensors shall be installed in brass, monel, or stainless steel wells filled with heat conducting compound. Use 4-20 ma sensors where necessary to meet accuracy requirements.
4. Duct Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Duct temperature sensors shall be rigid probe RTD type with a minimum range of 40 degrees F to 150 degrees F or averaging type as indicated. Use 4-20 ma sensors where necessary to meet accuracy requirements.

K. Differential and Static Pressure Sensors and Switches:

1. Fan proof-of-flow switches shall be adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WC, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WC.
2. Pump proof-of-flow switches shall be adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches shall have valved manifold for servicing.

L. Accessories:

1. Provide relays, transformers, and other accessories as required to provide a complete control system that performs the indicated functions.

2.10 SYSTEM APPLICATION CONTROLLER SOFTWARE

A. System Security:

1. User access shall be secured using individual security passwords for a minimum of eight users.
2. Passwords shall have at least three levels of user access with data entry restrictions being assignable by password.
3. User logon/logoff attempts shall be recorded.
4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.

B. Alarms:

1. The Building Automation System shall provide audio, visual, contact closure, and capability to expand for remote telephone annunciation for:
 - a. Remote equipment failure
 - b. Equipment run time
 - c. Number of start/stops
 - d. Program failure
 - e. Card failure
 - f. Sensor failure
2. Each analog sensor and binary point shall be individually alarmed for values in excess of individual high/low limits or status.
3. When an alarm state is detected, the alarm shall automatically be stored and the user notified by printing the alarm message, sounding an audible tone, and flashing an alarm message on the CRT.

2.11 COMMUNICATIONS

A. An autodial-up and auto-answer communications utility shall allow standalone System Application Controllers to communicate with remote operator stations over Ethernet.

1. Remote Alarming/Reporting:
 - a. Controllers shall automatically call/connect operator stations to report alarms, and upload historical data and reports.
 - b. In the event that the controller is unable to connect with the remote station, it shall continue to attempt communication on a predetermined interval until communication is successful. The capability shall exist to automatically switch to a backup phone number in the event communications is unsuccessful with the first number.
2. Remote Operator Communications:
 - a. Operators shall be able to connect by Ethernet remote System Application Controllers and gain access to the full control, reporting, and system modification capabilities described in this specification.
 - b. The operator shall connect by Ethernet remote buildings by selecting the user-definable name associated with the building. Manual dialing is not acceptable.

2.12 ENERGY MANAGEMENT SOFTWARE

A. Provide the following Energy Management capabilities as a standard part of the Building Automation System. Programs shall be enabled or disabled as required by the Owner.

B. Scheduling:

1. The scheduling program shall have a minimum of 32 named master schedules. Each master schedule shall have a minimum of eight day schedules (seven plus holiday).
2. To these master schedules, a minimum of 24 system loads (HVAC equipment etc) or groups of loads can be assigned.

3. The master schedule shall be individually editable for each day of the week and holiday. On any day, a minimum of six time of day events may be edited including:
 - a. equipment start/stop
 - b. optimum start/stop
 - c. occupied/unoccupied
 - d. duty cycle start/stop
 - e. night purge cycle start
- C. Optimum Start/Stop:
 1. An optimum start/stop program shall determine the required equipment start/stop timing by applying inside/outside temperature information to the user's time of day schedule.
 2. The optimum start/stop program shall run independently for each controlled load or zone.
 3. The program shall automatically make adjustments to itself based on historical data.
- D. Duty Cycling:
 1. The duty cycle program shall cycle a minimum of 32 pieces of equipment according to user-defined on/off patterns.
 2. User editable parameters are to include period length, off time and delay time. Program shall incorporate temperature and humidity overrides to ensure that Indoor Air Quality and occupant comfort are not compromised.

2.13 BUILDING MANAGEMENT SOFTWARE

- A. Provide the following Building Management capabilities as part of the Building Automation System.
- B. Timed Override:
 1. A timed override program shall be provided to enable the building operator to set up devices or groups of devices to be temporarily turned on for a defined period of time based on binary inputs, analog inputs, or CRT inputs.
 2. The override time shall be adjustable from 1 to 720 minutes.
 3. A standard weekly and monthly report shall be provided for easy documentation of timed override operation.
- C. Direct Digital Control:
 1. The Direct Digital Control program shall allow modulating control of remote devices based on sensed data.
 2. Standard control strategies shall include proportional, proportional plus integral, and proportional plus integral plus derivative control.
 3. Control routines shall be flexible enough to allow operator to set parameters and make adjustments.
 4. Direct Digital Control loop setup and modification shall be done through pre-formatted edit screens, with parameters listed in English language.

5. Program shall include a dynamic graphic display printout routine to indicate the status and real-time performance of the control loop.
- D. Custom Programming Language:
1. A custom control language capability shall be provided to allow the operator to create real time, equation based, custom control routines.
 2. All binary and analog points in the Building Automation System shall be available as inputs to the custom routines.
 3. Equation operations shall include math functions such as addition, subtraction, multiplication, division, square root, minimum, maximum, and average. Logical functions such as greater than, less than, equal to, not equal to, less than or equal to, greater than or equal to, variable timing and delays shall also be allowed.
- E. Run Time Maintenance:
1. The system shall monitor equipment status and generate maintenance messages based upon user designated run time, starts and/or calendar date limits.
 2. A minimum of 32 separate devices shall be monitored under this function.
- F. Expanded Messages:
1. The user shall be able to define a minimum of ten 34 character messages for automatic printing in the event of system alarm and/or run time and maintenance events.
- G. Reports and Logs:
1. The system shall include the capability to store, review and print the following reports and logs. In addition, if a PC interface is specified, these reports shall be saved to diskette as an ASCII file for use by other owner furnished software packages.
 2. Current Summary Report - An instantaneous summary of building status including heating and cooling degree days, on and off peak electrical demand performance, current electrical KWH consumption, and summary for critical temperature sensors listing today's minimum and maximum values.
 3. Monthly Summary Report - An end of the month summary of building status including heating and cooling degree days, on and off peak electrical demand performance, current electrical KWH consumption, and summary for critical temperature sensors listing this month's minimum and maximum values.
 4. Monthly Demand Limiting Report - A report for logging the electrical demand performance (both on and off peak), and the KWH consumption for each of the two utility meter programs shall be provided to the building operator. Included shall be the times of today's and yesterday's demand peaks as well as the time and date of the monthly demand peaks. This report shall log electrical performance for the present day and previous 32 days.
 5. Yearly Demand Limiting Report - A report for logging the electrical demand performance (both on and off peak) and KWH consumption for each of the two utility meter programs. This report shall log electrical performance for the present month and previous 12 months.

6. Yearly Meter Report - A report for logging the electrical KWH consumption for up to 6 submeters. This report shall log electrical performance for the present month and previous 12 months.
7. Yearly Degree Day Report - A current month and previous 12 month summary of heating and cooling degree days.
8. Weekly Temperature Report - A previous 7 day summary of the minimum and maximum temperatures for the critical zone temperature sensors.
9. Weekly Override Time Report - A previous 7 day summary of after hours override usage (in hours and minutes) for the timed override groups.
10. Monthly Override Time Report - A current and previous month summary of after hours override usage (in hours and minutes) for the timed override groups).
11. Trend Logs - A custom report generator allowing the user to trend and store at least 24 sample points based on a user-defined schedule.
12. Event Logs - The system shall track system events including alarms, logons and diagnostics.
13. Input/Output Status Reports - This reporting tool shall allow the operator to review the status of all system points.
14. HVAC Equipment Reports - Reports shall be provided which indicate the HVAC equipment status as well as the status of all input/output points of connected HVAC equipment.
15. Custom Report Capability - The building operator shall be provided with a simple method of creating custom reports.

H. Anti-Recycle Timer Protection:

1. A software program shall be provided to allow each individual piece of HVAC equipment to be individually programmable with "minimum on", and "minimum off" timers to protect HVAC equipment from rapid cycling due to system or operator error.
2. Minimum on/off timer program shall have priority over all application software functions except fire shutdown and smoke evacuation modes.
3. For system start-up purposes, timers shall be set at 15 minutes or at an acceptable time as documented by the HVAC equipment supplier.
4. Timers shall be individually programmable from 0 to 120 minutes.

I. Custom Programming Requirements:

1. A user-friendly custom DDC programming utility shall be provided to allow the building operator to tailor the system to meet individual needs and respond to changing building requirements.
2. The building operator shall be able to create custom DDC routines using analog and binary point values, alarm states, constants, and shared variables to perform calculations. The results of these calculations shall be used to perform analog control, binary control, DDC loop enable/disable, and other control functions.
3. Custom routines in distributed controllers shall be maintained in nonvolatile memory to prevent loss in a power outage. Custom routines hosted in Systems Applications controllers may use battery backup so long as a quick method of system downloading is provided.
4. Additional graphics shall be approved by Mechanical Systems Coordinator at School Plant.

2.14 CONTROL WIRING

- A. The wiring for all control devices is low voltage (24V) twisted shielded pair or twisted pair or line voltage (120V) as applicable to the device. All wiring must be installed in conduit unless otherwise noted.
- B. Each wire termination shall be labeled and wiring diagrams are to be provided for the entire system.

2.15 ELECTRIC WIRING

- A. The control contractor shall furnish and install all electrical control and interlock wiring required for the automatic temperature control system furnished hereunder. All power wiring shall be furnished and installed under Division 26 and 27, including power to Direct Digital Control System field panels and controllers and wiring to control transformer primaries.
- B. All electrical work performed under this section shall comply with the National Electrical Code, Underwriters' Laboratory where applicable and the Electrical Division of these specifications. Class II wiring for the automatic control system may be run without conduit provided the conductor insulation or jacket is designed for that purpose, and provided it is protected from physical damage. All control wiring in mechanical spaces must be in metallic conduit. Power line carrier devices may not be used. All system components and sensors must be hard wired.

2.16 VARIABLE FREQUENCY MOTOR DRIVES

The variable frequency drive (VFD) shall convert 240 or 460 volt (+/- 10%), three phase, 60 hertz (+/- 2Hz), utility grade power to adjustable voltage/frequency, three phase, AC power for stepless motor control from 5% to 105% of base speed.

A. Description

The variable frequency drive (VFD) shall produce an adjustable AC voltage/ frequency output for complete motor speed control. The VFD must meet all of the following criteria:

- 1. The VFD shall use sine coded Pulse Width Modulation (PWM) technology. The sine coded PWM calculations are performed by the VFD microprocessor.
- 2. The VFD shall use Insulated Gate Bipolar Transistors (IGBT) transistors for the inverter's three phase output.
- 3. The VFD shall use a three phase diode bridge converter to charge the VFD constant voltage capacitor buss.
- 4. The VFD shall have the ability for control by either a remote 4-20 mA control signal or from a local control panel located on the VFD itself.
- 5. The VFD shall use microprocessor technology for VFD control. The VFD shall be programmable with a permanently mounted keypad included with each VFD.
- 6. The VFD shall be fully self diagnostic. No external programmers, analyzers, interrogators, or diagnostic boards, shall be needed to annunciate VFD faults or drive internal status.

B. Code Standards

VFD shall be UL listed as delivered to the end user. The VFD shall meet current National Electrical Code.

C. VFD Quality Assurance

To ensure quality, each and every VFD shall be subject to a series of in-plant quality controlled inspections before approval for shipment from the manufacture's facilities.

1. All components shall be tested prior to assembly and the complete unit shall be tested under full load conditions to ensure maximum product reliability.
2. The VFDs shall be the current standard production unit with at least 10 identical units already in the field.
3. Engineering support shall be available from the factory of the VFD. Phone support shall be free of charge to the end user for the life of the equipment. Factory support shall be available in the English language.

D. VFD Service

The VFD shall be supplied with:

1. 24 month parts and labor warranty. The warranty shall start when the system is accepted by the end user or 30 months from date of shipment.
2. Installation, operation, and troubleshooting guide(s).
3. A district service support group shall provide the following additional services:
 - a. Factory trained personal on-site for start-up for up to one working day at no additional cost. Personnel shall be competent in operation and repair of the particular model of VFD that is installed.
 - b. On-site training of customer personnel in basic installation, troubleshooting, and operation of VFDs at no additional cost. This training shall be conducted for up to 6 personnel at the installation site for a minimum of 4 hours.

E. Basic VFD Features

The VFD shall have the following basic features with no more than three separate internal electronic boards.

1. VFD mounted operator control keypad capable of:
 - a. Remote/Local operator selection with password access.
 - b. Run/Stop and manual speed commands.
 - c. All programming functions.
 - d. Scrolling through all display functions.
2. Digital display capable of indicating:
 - a. VFD status.
 - b. Frequency.
 - c. RPM of motor.
 - d. Phase current.
 - e. Fault diagnostics in descriptive text.

- f. All programmed parameters.
3. Standard PI loop controller with input terminal for controlled variable and parameter settings made while inverter running.
4. User interface terminals for end-user remote control of VFD speed, speed feedback, and isolated form C SPDT relay energized on drive fault condition.
5. An isolated form C SPDT auxiliary relay energized on run command.
6. The VFD shall have a metal NEMA 1 enclosure.
7. The VFD shall have an adjustable carrier frequency with 16 KHz minimum upper limit and 2 KHz minimum lower limit.
8. The VFD shall have a built in or external line reactor with 3% minimum impedance to protect DC buss capacitors and rectifier section diodes.

F. Programmable Parameters

The VFD shall include the following operator programmable parameters:

1. Upper limit frequency.
2. Lower limit frequency.
3. Acceleration rate.
4. Deceleration rate.
5. Variable torque volts per Hertz curve.
6. Starting voltage level.
7. Starting frequency level.
8. Display speed scaling.
9. Enable/disable auto-restart feature.
10. Enable/disable soft stall feature.
11. Motor overload level.
12. Motor stall level.
13. Jump frequency and hysteresis band.
14. PWM carrier frequency.

G. Protective Circuits and Features

1. An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.
2. An electronic adjustable soft stall feature, allowing the VFD to lower the frequency to a point where the motor will run at FLA when an overload condition exists at the requested frequency. The VFD will automatically return to the requested frequency when load condition permit.
3. The VFD will have a separate electronic stall at 110% VFD rated current and a separate hardware trip at 190% current.
4. The VFD shall have ground fault protection that protects output cables and motor from grounds during both starting and continuous running conditions.
5. The VFD shall have the ability to restart after the following faults:
 - a. Overcurrent (drive or motor).
 - b. Power outage.
 - c. Phase loss.
 - d. Overvoltage/Undervoltage.
6. The VFD shall restart into a rotating motor operating in either the forward or reverse direction without tripping or damaging the VFD or the motor.

7. The VFD shall keep a log of a minimum of four previous fault conditions, indicating type and time of occurrence in descriptive text.
8. The VFD shall be able to sustain 150% rated current for 60 sec.
9. The VFD shall respond to and record the following fault conditions:
 - a. Over current (and have an indication if the over current was during acceleration, deceleration, or running).
 - b. Overcurrent internal to the drive.
 - c. Motor overload at start-up.
 - d. Over voltage from the utility power.
 - e. Motor running overload.
 - f. Overvoltage during deceleration.
 - g. VFD over heat.
 - h. Load end ground fault.
 - i. Abnormal parameters or data in VFD EEPROM.

H. Operational Conditions

The VFD shall be designed and constructed to operate within the following service conditions.

1. Ambient Temperature Range, 15 to 120 deg. F.
2. Non-condensing relative humidity to 90%.
3. Vibration – 0.6G maximum.

I. Available Options

Provide the following options:

1. RFI/EMI filters
2. RS232 or RS422/485 interface card with application software which can both control and monitor the VFD from attached computer.
3. A manual bypass circuit and switch integral to the drive to allow drive bypass and operation at 100% speed. Overload fuses and other protective hardware shall remain in the circuit during bypass.
4. UL listed disconnecting means.

2.17 SEQUENCE OF OPERATION

Refer to drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all items in accordance with the manufacturer's instructions.
- B. The control equipment and wiring shall be installed in a neat and workmanlike manner. All wiring and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces.

- C. Thermostats, wall switches, and wall timers shall be located as shown on drawings and mounted at the indicated height above finished floor. Devices shall be mounted in metal wall boxes.
- D. Install control valves in vertical position whenever possible, and in no case shall control valves be installed below a horizontal position.
- E. Install control panels in an approved location, convenient for adjustment and service.
- F. The BCS contractor shall enter all computer programs and data files into the related computers including all control programs, initial approved parameters and settings, and English descriptors.
- G. The BCS contractor shall maintain diskette copies of all data file and application software for reload use in the event of a system crash or memory failure. One copy shall be delivered to the owner during training session, and one copy shall be archived in the BCS contractor's local software vault.

3.2 VALIDATION

- A. The BCS contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations submitted.
- B. Witnessed validation demonstration shall consist of:
 - 1. Display and demonstrate each type of data entry to show site specific customizing capability. Demonstrate parameter changes.
 - 2. Execute digital and analog commands.
 - 3. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs.
 - 4. Demonstrate EMS performance via trend logs and command trace.

3.3 VERIFICATION OF HVAC CONTROL SYSTEM

- A. The TAB agency shall coordinate with and be assisted by building controls contractor in verifying the operation and calibration of all HVAC and temp control systems. Verify all components are installed in accordance with project requirements and are functional including all electrical interlocks, damper sequences, air and water resets, fire and freezestats and other safety devices.
- B. TAB Support: Coordinate onsite meetings with TAB Contractor for DDC manipulation during TAB procedures.

3.4 MANUALS

The following manuals will be provided:

- A. An Operators Manual shall be provided with graphic explanations of keyboard use for all operator functions specified under Operator Training.

- B. Computerized printouts of all DCP data file construction including all point processing assignments, terminal relationships, scales and offsets, command and alarm limits, program flowcharts, etc.
- C. An As-Built Manual shall be provided including revised as-built documents of all materials required under the paragraph "SUBMITTALS" on this specification.
- D. Two Operators Manuals, and two As-Built Manuals shall be provided to the owner.

3.5 TRAINING

- A. All training shall be by the BCS contractor and shall utilize specified manuals and as-built documentation.
- B. Operator training shall include three four-hour sessions encompassing:
 - 1. Sequence of Operation review.
 - 2. Selection of all displays and reports.
 - 3. Use of Operators Interface.
 - 4. Troubleshooting of sensors (determining bad sensors).
 - 5. Password assignment and modification.
 - 6. The first training session shall be prior to building occupancy. The second session shall be 30 days after building occupancy. The third session shall be three months after building occupancy.

3.6 WARRANTY

- A. All components, system software, parts and assemblies supplied by the BCS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date.
- B. Labor to troubleshoot, repair, reprogram, or replace system components shall be furnished by the BCS contractor at no charge to the owner during the warranty period.
- C. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.
- D. Provide four 4-hour sessions during the warranty period for program modifications desired by owner or additional training.

END OF DIRECT DIGITAL CONTROL SYSTEM

SECTION 16010
ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The General Conditions, Supplementary General Conditions, and Special Conditions of this Contract form a part of this Division of Specification.
- B. This section forms a part of all sections under Division 16 Electrical.
- C. Requirements herein augment or clarify articles specified under aforementioned General and Special Conditions.

1.2 QUALIFICATIONS FOR BIDDERS

- A. Before submitting bid, visit the site and examine all adjoining existing equipment and space conditions on which work is in any way dependent, for the best workmanship and operation according to the intent of specifications and drawings. Report to the Engineer any condition which might prevent the installation of the equipment in the manner intended.

1.3 CODES AND STANDARDS

- A. Latest effective publications of following standards, codes, etc., as they apply, form part of these specifications as if were written fully herein and constitute minimum requirements. Minimum requirements shall not relieve the Contractor of the responsibility of furnishing and installing higher grade materials and workmanship than herein specified. The following will be referred to throughout in abbreviated forms.
 - 1. National Electrical Code, (NFPA 70) (NEC)
 - 2. Standard Rules of Institute of Electrical and Electronic Engineers (IEEE)
 - 3. Rules and Regulations of Local Electric Utility Company
 - 4. Applicable Standards of the National Electrical Manufacturer's Association (NEMA)
 - 5. Applicable Standards of the American National Standards Institute (ANSI)
 - 6. Applicable Local Codes
 - 7. Virginia Uniform Statewide Building Code 2006
 - 8. Applicable Standards and Lists of the Underwriter's Laboratories, Inc. (UL)
 - 9. Applicable Standards of the National Fire Protection Association (NFPA)
 - 10. International Building Code (IBC) 2006

11. The Americans with Disabilities Act (ADA)
12. International Electrical Testing Association (NETA)

1.4 SCOPE OF WORK

- A. Provide all work required for this Division including all labor, materials, equipment, appurtenances and services to provide complete electrical systems as shown on the drawings and specified in this Division of the specifications. The word "Provide" shall mean "Furnish and Install Complete and Ready for Use". The work includes, but is not limited to the following:
 1. Interior and exterior electrical lighting system including fixtures, lamps, time switches, and equipment.
 2. Power wiring system, including outlets, receptacles, switches, wire, conduit, junction boxes, panelboards, switchboards and modified electric service.
 3. Disconnect switches and power wiring up to and including motor connections for all equipment provided under other Divisions of this specification shall be included in this Division. Where manual motor control switches for single phase motors are indicated, they shall be provided and wired complete under this Division. Motor controllers and motor starters furnished under other Divisions shall be set in place and connected to source and load under this Division. In general, motors will be provided with the equipment they drive and are not part of this work under this Division, except that they shall be connected hereunder.
 4. System of empty conduits, outlet boxes and cable tray for telephone, computer and other communication systems.
 5. Modification of existing Fire Alarm System and control center.
 6. Exit and emergency lighting systems.
- B. The following work is not included in this Division:
 1. Heating, ventilating, and air conditioning equipment and all associated motors and magnetic motor starters.
 2. Plumbing equipment except as specifically indicated.
 3. Control, interlock, and internal equipment wiring regardless of voltage.

1.5 DRAWINGS AND SPECIFICATIONS

- A. The drawings are diagrammatic and indicate the general extent, character and arrangement of equipment, fixtures and conduit and wiring systems. If any departures from the contract drawings are deemed necessary, submit details of such departures and the reasons therefore as soon as practicable after award of contract to the Engineer for approval. Make no such departures without prior written approval of the Engineer.

- B. It is the intention of these specifications and drawings to fully cover all work and materials for a complete, first-class electrical installation, and any devices such as pull boxes and disconnect switches, usually employed in this class of work, though not specifically mentioned or shown on the drawings or in this specification, but which may be necessary for the satisfactory completion of the work, shall be furnished and installed by the Contractor as a part of his total work under this Division. Consult the specifications and drawings of all other trades and perform all electrical work required therein. Cooperate with all other contractors or subcontractors to furnish complete workable systems.
- C. In case of conflicting information on the drawings and/or in the specifications, the proper interpretation shall be made by the Engineer.
- D. Disagreements occurring between trades covering various phases of the work shall be referred to general Contractor for final decision.
- E. Changes and additions to scope of the work under this contract shall be submitted to the Engineer and his written approval obtained before proceeding with the changed work.
- F. During construction, the Electrical Subcontractor shall keep an accurate record of all deviations between the work as shown on the contract drawings and that which is actually installed. He shall secure a set of blue line prints of the electrical drawings for this purpose, and note changes thereon with red marks, in a neat and accurate manner, thus making a complete record of all changes and revisions in the original design which exist in the completed work. The cost of furnishing above prints and preparing these record drawings shall be borne by the subcontractor, and shall be included in the contract price. When all revisions have been shown on these prints to indicate the work as finally installed, the prints shall be delivered to the Engineer, before final payment.

1.6 PERMITS, INSPECTION AND TESTS

- A. The right is reserved to inspect and test any portion of the installation/equipment during the progress of its erection. Test all wiring for continuity and grounds before connecting any fixtures or devices. Perform insulation resistance tests on wiring #6 or larger. Test the entire system when the work is finally completed to insure that all portions are free from short circuits and grounds. Provide all equipment necessary to conduct the above tests.
- B. Secure and pay for all required permits and inspections. Inspection certificates from local authorities having jurisdiction shall be delivered to the Owner before final payment.

1.7 SUBMITTALS

- A. Submit Shop Drawings, Product Data and Samples within thirty (30) days of award of contract and in accordance with the General Conditions and Supplementary Conditions. Review of submittals by the Engineer and any associated action taken by the Engineer does not relieve the contractor of any requirements set forth by the contract documents. Submittals are required for the following items if and only if those items are specified herein.
 - 1. Panelboards
 - 2. Switchboard

3. Transformers
4. Lighting Fixtures and Occupancy Sensors
5. Transient Voltage Surge Suppression (TVSS)
6. Fire Alarm System Components
7. Any Special Systems as specified herein (i.e. Access Control, CCTV, etc.)

B. Submittals shall contain:

1. The date of submission and of any previous submissions.
2. The project title and number.
3. Contract or project identification.
4. The names of:
 - a. Contractor.
 - b. Supplier.
 - c. Manufacturer.
5. Identification of the product, and specification section.
6. Field dimensions, clearly identified as such.
7. Relation to adjacent or critical features or materials.
8. Applicable standards.
9. Identification of deviations from Contract Documents.
10. Identification of non-complying features and reason for the non-compliance. The reason shall be specific in nature.
11. Identification of revisions on resubmittals.
12. Contractor's stamp, initialed or signed, certifying to review of submittal, verification of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.

C. SUBSTITUTIONS

1. For a period of 10 days after Contract date, Engineer will consider written requests from Contractor for substitution of products.
2. Submit a separate request for each product, supported with complete data, with drawings and samples as appropriate, including:

- a. Comparison of the proposed substitution with that specified.
 - b. Changes required elsewhere because of the substitution.
 - c. Effect on the construction schedule.
 - d. Cost comparison of the substitution and product specified.
 - e. Availability of maintenance service, and replacement parts.
3. The Engineer shall be the judge of the acceptability of the proposed substitution.
4. A request for a substitution constitutes a representation that the Contractor:
- a. Has investigated the proposed product and determined that it is equal to or superior in all respects to that specified.
 - b. Will provide the same warranties or bonds for the substitution as for the product specified.
 - c. Will coordinate the installation of an accepted substitution into the work, and make such other changes as may be required to make the work complete in all respects.
 - d. Waives all claims for additional costs, under his responsibility, which may subsequently become apparent.

PART 2 - PRODUCTS

2.1 MANUFACTURING STANDARDS

- A. Materials shall be new and approved and labeled by UL wherever standards have been established by that agency. Defective equipment or equipment damaged in the course of installation or test shall be replaced or repaired in a manner meeting the approval of the Engineer. Materials to be furnished under this specification shall be the standard products of manufacturers regularly engaged in the production of such equipment and shall be the manufacturer's latest standard design. All items of the same type and rating shall be identical.

2.2 TRADE NAMES

- A. Unless specifically identified otherwise, manufacturers' names and catalog numbers indicated herein and on the drawings are not intended to be proprietary designations. They are to indicate general type and quality of materials and equipment required. Equipment and materials by other manufacturers which in the opinion of the Engineer are of equal quality and which will produce the same results with regard to both their ability to perform the required technical functions as well as to their appearance in the specific location on this project will be considered.

2.3 MOTORS AND EQUIPMENT

- A. All motors shall have disconnecting means, controller and thermal overload protection. All three phase motors shall have power loss, phase outage, and phase reversal protection features.
- B. Provide motors, controllers, integral disconnects, and contactors with their respective pieces of equipment. Motors, controllers, integral disconnects, and contactors shall conform to the requirements defined under the electrical provisions of the specifications. Extended voltage range motors shall not be permitted. Control voltage for controllers and contactors shall not exceed 120 volts nominal. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work shall be included under the section that specified that motor or equipment. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.
- C. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment under the electrical provisions of the contract. Control wiring and conduit shall be provided under the section specifying the associated equipment. Wiring and conduit for power systems and control systems shall conform to the requirements defined under the electrical provisions of the specifications.

2.4 ELECTRICAL SERVICE

- A. Provide modification to the existing electrical service as indicated. All arrangements shall be as indicated with proper extension, terminations, provisions and necessary materials for final connections by the local power company. Service and all metering shall be provided in accordance with the latest regulations of the local power company. The local power company may provide the meter and current transformers and may participate in the cost of supplying service to the building. Consult the local power company and determine limit of this participation. The bid on electrical work shall reflect this participation except that any charges which the local power company proposes to make for supplying service will be paid directly by Owner and will not be part of this contract.
- B. Short circuit ratings for all panelboards, main disconnect switches, etc. shall be suitable to accommodate the Power Company's available fault current.

2.5 TEMPORARY ELECTRICAL SERVICE

- A. Reasonable amounts of electricity will be made available to the Contractor for the project. The Contractor shall be responsible for extending the electricity to the specific required locations within the project.

2.6 GROUNDING

- A. The entire electrical system, including equipment frames, conduit, switches, controllers, wireways, neutral conductors, and all other such equipment shall be permanently and effectively grounded in accordance with the NEC. Ground rods shall be copper clad steel, 3/4" diameter by 10'-0" long. Grounding of each transformer secondary shall be provided and each shall be considered as a separate service ground. Provide a separate ground conductor in all branch circuit conduits sized in accordance with the N.E.C. Provide

minimum #6 ground conductor in conduit from the building main service ground to the telephone backboard.

PART 3 - EXECUTION

3.1 SCHEDULE OF WORK

- A. The schedule of the electrical work shall be arranged to suit the progress of work by the other trades and shall in no way retard progress of construction of the project.
- B. Work under this Division shall proceed in advance of the work of others whenever possible, eliminating all cutting and patching. When such procedure is impossible, cutting and patching shall be done in an approved manner. Cutting shall not endanger structural integrity in any way. Patching shall exactly match contiguous work. Actual work of cutting and patching of existing surfaces shall be performed by the subcontractor who originally prepared these surfaces, e.g., cutting and patching of masonry wall will be performed by the masonry subcontractor. Costs of such cutting and patching shall be borne by the Electrical contractor. Cutting shall be carefully done and damage to building, piping, wiring or equipment as a result of cutting shall be repaired by skilled mechanics of trade involved.

3.2 STORAGE AND MATERIALS

- A. Space will be assigned to the Contractor by the Owner for the storage of materials. This Contractor will be responsible for the protection and safekeeping of materials, tools, and equipment. All materials and equipment shall be kept in its assigned place until the time of its installation. Excess materials, dirt and refuse shall be promptly removed from the work site.

3.3 LABELING OF EQUIPMENT

- A. All panelboards, cabinets, transformers, safety switches, motor disconnect switches, and motor controllers shall be identified by machine engraved laminated plastic designation plates permanently attached thereto with self-tapping screws or rivets. All component parts of each item of equipment or device shall bear the manufacturer's nameplate, giving name of manufacturer, description, size, type, serial and model number and electrical characteristics in order to facilitate maintenance or replacement. The nameplate of a subcontractor or distributor will not be acceptable. Self-adhesive, plastic laminate labels are not acceptable.
- B. All switchboards, panelboards, industrial control panels, and motor control centers shall be field marked to warn personnel of the potential for Arc Flash. Labels shall state "WARNING – ARC FLASH AND SHOCK HAZARD APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED".

3.4 OTHER TRADES

- A. Excavation shall be performed in accordance with the section of these specifications which cover excavating, filling and backfilling.
- B. Concrete work shall be performed in accordance with the section of these specifications which cover concrete.

- C. Painting shall be performed in accordance with the section of these specifications which cover painting. Paint all exposed conduit as well as cabinets and related items which are not supplied with a factory finish. Touch up all factory finishes damaged during installation or by adjacent construction work.

3.5 COORDINATION

- A. Cooperate and coordinate efforts with all Contractors on the project. This is especially important in determining exact locations of all switches, receptacles and lighting fixtures. Arrange lighting fixtures in accordance with the architectural reflected ceiling plans unless otherwise indicated. Coordinate lighting fixture locations with grilles, diffusers, access panels, etc. Verify ceiling and wall construction and material prior to ordering lighting fixtures or other devices to ensure proper fixture or device is furnished to match construction. This verification must be executed regardless of information placed on the drawings. Any cost incurred which in the opinion of the Engineer, could have been avoided by this step shall be the responsibility of the Contractor. Coordinate switch locations with thermostats, control switches, etc.
- B. Carefully check space requirements with the other subcontractors to insure that electrical equipment can be installed in the spaces allotted for them. Sufficient access and working space shall be provided and maintained about all electrical equipment as required by the National Electrical Code. Consult all applicable drawings for details. Where interferences occur and work must be relocated, relocate without additional cost.
- C. No conduit, outlet box, conduit stub-up, or any other electrical devices shall be installed until the exact location has been determined by the coordinated effort of all Subcontractors and other parties concerned. Any relocating of devices or cutting or patching which becomes necessary due to improper coordination shall be done at this Contractor's expense.
- D. Determine electrical requirements of other Divisions in order to fully understand wiring, and provide as required for complete and satisfactory operation of project. Make connections for other Divisions where indicated.
- E. Obtain approved shop drawings showing wiring diagrams, connection diagrams, roughing-in and hookup details, from other involved contractors for all equipment and comply therewith.

3.6 GUARANTEE OF WORK

- A. Contractor guarantees by his acceptance of the contract that all work installed is free from any and all defects in workmanship and/or materials, and that the apparatus will develop capacities and characteristics specified, and that if, during the period of one year or as otherwise specified, from date of certificate of completion and acceptance of the work any such defects in workmanship, material or performance appear, he will, without cost to the Owner, remedy such defects within a reasonable time to be specified in notice from Engineer. In default thereof, the Owner may have such work done and charge cost to Contractor. Equipment guarantees from date of "start-up" will not be recognized.
- B. Comply, also, with the General Conditions and the Supplementary Conditions and the applicable Sections of Division 1 General Requirements.

- C. Provide service for the installation for one year from date of final acceptance. This shall include all emergency service and adjustment. Provide evidence upon request by the Engineer that a factory authorized local service organization is in existence to service and furnish spare and replacement parts for all equipment under this Division of the specifications.
- D. Compile and assemble and provide all shop drawings, maintenance manuals, operation manuals and warranties in a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

3.7 CLEANING

- A. Refer to the Division 1 Section "PROJECT CLOSEOUT" or "FINAL CLEANING" for general requirements for final cleaning.
- B. Clean all light fixtures, lamps and lenses prior to final acceptance. Replace all inoperative lamps.

END OF ELECTRICAL GENERAL PROVISIONS

SECTION 16134
CABLE TRAYS - LADDER TYPE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The provisions of the Contract Documents apply to the work of this section.

1.2 SUMMARY

- A. Section includes cable tray.

1.3 REFERENCES

- A. ASTM A123 - Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip.
- B. ASTM A525 - General Requirements for Steel Sheet, Zinc-Coated Galvanized by the Hot-Dip Process.
- C. NEMA FG 1 (National Electrical Manufacturers Association) - Fiberglass Cable Tray Systems.
- D. NEMA VE 1 (National Electrical Manufacturers Association) - Metallic Cable Tray Systems.
- E. NEMA VE 2 (National Electrical Manufacturers Association) - Metallic Cable Tray Installation Guidelines.

1.4 SUBMITTALS

- A. Shop Drawings: Indicate tray type, dimensions, support points, and finishes.
- B. Product Data: Submit fittings and accessories.
- C. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

PART 2 - PRODUCTS

2.1 METAL LADDER-TYPE CABLE TRAY

- A. Product Description: NEMA VE 1, Class 12C ladder type tray.
- B. Material: Aluminum.
- C. Inside Width: As indicated on Drawings.

- D. Inside Depth: As indicated on Drawings.
- E. Straight Section Rung Spacing: 6 inches on center.
- F. Inside Radius of Fittings: minimum 12 inches.
- G. Furnish manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.

2.2 WARNING SIGNS

- A. Engraved Nameplates: 1/2 inch black letters on yellow laminated plastic nameplate, engraved with the following wording:
WARNING! DO NOT USE CABLE TRAY AS WALKWAY, LADDER, OR SUPPORT.
USE ONLY AS MECHANICAL SUPPORT FOR CABLES!

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install metal cable tray in accordance with NEMA VE 2.
- B. Support trays and fasten to structure and finishes in accordance with Section 16210, and the manufacturer's instructions and recommendations. Install supports at each connection point, at end of each run, and at other points to maintain spacing between supports of 10 ft maximum.
- C. Install expansion connectors where recommended by manufacturer.
- D. Install firestopping in accordance with the Section of specifications covering firestopping to sustain ratings when passing cable tray through fire-rated elements.
- E. Ground and bond all metal cable tray.
 - 1. Provide continuity between tray components.
 - 2. Use anti-oxidant compound to prepare aluminum contact surfaces before assembly.
 - 3. Install #4 AWG bare aluminum equipment grounding conductor through entire length of tray; bond to each component.
 - 4. Make connections to tray using mechanical or compression connectors.

END OF CABLE TRAYS – LADDER TYPE

SECTION 16210

RACEWAY, FITTINGS AND BOXES

PART 1 - GENERAL

- 1.1 Provide raceways and fittings for all electrical and related systems where indicated, specified or required to form continuous raceways from the various service entrances to the various outlets.
- 1.2 Provide each outlet in the raceway system with an outlet box to suit the conditions encountered. Each box shall have sufficient volume to accommodate the number of conductors and conduits entering the box.
- 1.3 All wiring shall be in conduit. As an exception, metal-clad type MC cable shall be allowed for branch circuits #8 AWG and smaller, where allowed by the NEC.

PART 2 - PRODUCTS

2.1 RACEWAYS

- A. Conduit shall be hot-dipped, zinc coated or sherardized rigid steel (RS), intermediate metal conduit (IMC), electrical metallic tubing (EMT), or schedule 40 polyvinyl chloride (PVC).
- B. Flexible conduit shall be galvanized, continuous spiral, single strip type. Flexible conduit shall be covered with PVC jacket in wet or damp locations. Provide suitable fittings with ground connector.
- C. Surface metal raceway system shall be Panduit pan-way PMR40 series. It shall consist of an 0.040 inch thick formed steel assembly and an 0.025 inch thick steel, snapping cover plate. Finish shall be gray enamel inside and out over a corrosion-resistant metal treatment undercoat. Surface metal raceway shall be complete with end caps, coupling devices, wire clips, device plates, box connectors, wiring devices and accessories.

2.2 FITTINGS

- A. All conduit entering or leaving outlet, junction or pull boxes, and cabinets and all conduit stubs shall have bushings. Provide insulating bushings where required by NEC.
- B. Provide expansion fittings with bonding jumper where conduits cross expansion joints.
- C. Fittings for RS and IMC shall be threaded type.
- D. Fittings for EMT shall be threadless, approved for the conditions encountered and may be cast setscrew type or compression type.
- E. Fittings for PVC shall be PVC, primed and glued.
- F. Provide insulating wedge type cable supports in riser conduits in multi-story buildings.

2.3 SLEEVES

- A. All electrical system conduit shall have sleeves where conduit passes through concrete slabs except concrete slabs in contact with grade. All conduit 1 1/4 inch and larger running concealed above ceiling shall have sleeves where the conduit passes through masonry, tile and gypsum wall construction. All conduit running exposed below ceiling or in area without finished ceiling construction and passing through masonry concrete, tile and gypsum wall construction shall be provided with sleeves.
- B. Sleeves shall be constructed of galvanized steel pipe, Schedule 40.
- C. Provide escutcheon plates for all exposed conduit passing through walls, floors and ceilings. Plates shall be nickel plated, of the split ring type of size to match the pipe or conduit. Where plates are provided for conduits passing sleeves which extend above the floor surface, provide deep recessed plates to conceal the sleeves.

2.4 OUTLET BOXES AND JUNCTION BOXES

- A. Outlet boxes shall be pressed steel, electro-galvanized or cadmium plated with clean cut, easily removable knockouts. Except as noted hereinafter minimum size outlet box shall be 4" square, 1 1/2" deep, and shall be increased in dimensions to accommodate conductors, conduits, and devices as required by the NEC. Shallower boxes may be used where required by structural conditions and when specifically approved by the Architect/Engineer. Provide suitable plaster-rings to match wall construction and device. Ceiling and bracket outlet boxes shall not be less than 4" octagonal, 1 1/2" deep except that smaller boxes may be used where required by particular fixture to be installed.
- B. Floor boxes shall be manufactured by Walker, and shall be of the rectangular cast iron type, fully adjustable, and shall be provided with all necessary carpet rings and other fittings as required. All floor boxes shall be of the maximum depth possible for the locations indicated.
- C. Non metallic outlet boxes may be provided in PVC raceway systems.
- D. Outlet boxes in wet or damp locations shall be cast-metal, threaded hub-type with gaskets.
- E. Outlet boxes in masonry-block or tile walls shall be square-cornered masonry-type with tile type covers.
- F. Junction or pull boxes not over 100 cubic inches in volume shall be standard outlet boxes. Junction boxes over 100 cubic inches in volume shall be constructed of code gage, galvanized sheet steel. Junction boxes shall have removable covers and shall be accessible after completion of buildings.

2.5 CABINETS

- A. Cabinets shall be zinc-coated sheet steel, constructed with interior dimensions not less than those indicated on drawings, arranged for flush or surface mounting as indicated. Removable trim shall be provided with a hinged door and flush latch and lock. Locks shall be keyed same as panelboards.

2.6 ACCESS PANELS

- A. This Contractor shall furnish and General Contractor shall install access doors where required for electrical access, style as necessary for surface in which placed, sized as required, with cylinder lock. Interior doors shall be steel and exterior doors shall be aluminum. Access doors shall have same fire rating as ceiling, walls and/or partitions in which they are to be installed.

PART 3 - EXECUTION

3.1 RACEWAY AND FITTING INSTALLATION

- A. Conduits within building shall be GRS, IMC or EMT unless otherwise noted. Run conduits concealed within finished walls, ceilings and floors where possible, except where indicated on drawings to be run exposed. In addition, conduits may be run exposed in mechanical rooms and spaces with exposed construction when approved by the Engineer. Conduit shall be supported at intervals of not more than 8'. Run exposed conduit parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceiling. Conduit in areas with suspended ceilings shall be located when practicable between the structural system and the ceiling. All conduit to be run under the floor shall be run under the slab. Conduit shall not be run in the floor slab, except as required to feed floor boxes. Do not stack conduits beneath slab. Changes in direction of runs shall be made with symmetrical bends or cast metal fittings.
- B. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces.
- C. Support conduits by pipe straps, wall brackets, strap hangers, or ceiling trapeze.
- D. Conduit run outside of building shall be buried a minimum of 24" below finished grade.
- E. Do not install EMT outdoors, or underground, or encased in concrete, or in hazardous areas, or in areas subject to severe physical damage.
- F. Do not install PVC in or through fire rated assemblies, in or through any walls, in or through any ceilings, in hazardous areas, in areas subject to severe physical damage, or exposed anywhere in the project.
- G. Conduit run underground, under slab, or within concrete encasement may be polyvinyl chloride (PVC) or RS or IMC conduit protected with 2 coats of bitumastic paint at the Contractor's option, unless another specific type of conduit is indicated. Convert PVC to RS or IMC before rising through floor slab or rising out of soil where conduit will be exposed. Where conduit is to be concealed within a wall, PVC may be stubbed up to the first outlet box or panelboard back-can. All conduit from that point on shall be metallic. Conduit run beneath slab shall be properly suspended from slab such that sub-slab settlement will not adversely affect electrical system.
- H. Service entrance conduits shall be concrete encased PVC or direct-buried RS.
- I. Flexible conduit shall be used to connect all motors, transformers and all equipment subject to vibration.

3.2 SLEEVE INSTALLATION

- A. Check floor and wall construction and finishes to determine proper length of sleeves for various locations. Make actual lengths to suit the following:
 - 1. Terminate sleeves flush with wall, partitions and ceilings.
 - 2. In areas where conduits are concealed, as in chases, terminate sleeves flush with floor.
 - 3. In finished areas, where conduits are exposed, extend sleeves 1/2 inch above finished floor, except in rooms having floor drains extend sleeves 1 inch above floor.
- B. Fasten sleeves securely in floors and walls, so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into the spaces between conduit and sleeve during construction.
- C. Where sleeves pass through floors or fire rated walls provide proper sealant around conduit to maintain fire rating.

3.3 BOX INSTALLATION

- A. Support boxes for fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. Nail-type nylon anchors may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

END OF RACEWAY, FITTINGS AND BOXES

SECTION 16220

CONDUCTORS

PART 1 - GENERAL

- 1.1 Provide a complete system of conductors as indicated or necessary to accomplish the required connections. All conductors shall be installed in a neat and workmanlike manner, with care being taken that conductors are not kinked, scarred, or damaged during installation.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND INSULATION

- A. Wire and cable shall be soft drawn, annealed copper with 600 volt insulation. Minimum wire size shall be #12 AWG. Insulation for conductor sizes #12 and #10 shall be type THHN-THWN, THW or RHW for installation in ordinary dry locations and type THWN or RHW-2 for installation in wet locations. Wet locations shall include service conduits, conduit underground, raceways installed in concrete floor slabs in direct contact with the earth and raceways regularly subject to moisture or condensation. Conductors sizes larger than #10 shall have type XHHW-2 insulation. Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote-control and signal circuits, classes 1, 2, and 3, may be stranded.
- B. Branch circuit conductors in fluorescent fixture raceways and drops to single fluorescent fixtures shall be type THHN or XHHW.
- C. Provide a separate ground conductor in all raceways sized in accordance with the N.E.C.

2.2 COLOR CODING

- A. All branch circuit, feeder and control wiring shall be color coded in accordance with NEC. Color shall be integral with sheath for sizes 12 through 8. Provide minimum 1/2 inch wide color coded plastic tape strips for conductors size 6 and larger. Strips shall be placed minimum 6 inches on center in all panelboards, junction boxes, pull boxes, conduit fittings, disconnect switches and anywhere the conductors are accessible and visible. Wire shall be color coded as noted below. All other conductors shall be of other colors. Color schedule shall be as follows:

<u>208/120 Volt System</u>		<u>480/277 Volt System</u>	
Phase A	Black	Phase A	Brown
Phase B	Red	Phase B	Orange
Phase C	Blue	Phase C	Yellow
Neutral	White	Neutral	Grey
Ground	Green	Ground	Green

2.3 ALUMINUM CONDUCTORS

- A. Electrical designs are based on copper wire and cable. If at option of the Contractor, aluminum or copper-clad aluminum is selected for cables No. 6 AWG or larger, equivalent aluminum or copper-clad aluminum conductor sizes shall be selected and provided by the Contractor. Additionally, all adjustments in raceway and pull box sizes shall be the responsibility of the Contractor.
- B. The manufacturers of certain air conditioning system components and certain other equipment place restrictions and prohibitions on the use of aluminum conductors in their equipment. Before adopting the option of using aluminum or copper-clad aluminum conductors to feed this equipment, the Contractor must check for such restrictions and prohibitions and abide by them. No requests for extra compensation for changing conductor type in these circuits will be considered.

2.4 JOINTS AND TERMINATIONS

- A. Leave at least 6 inches of free conductor in each outlet- or junction- box for making up joints and making connections to fixtures, devices or equipment.
- B. For conductors #12 and #10 all fixture and branch circuit joints in junction and outlet boxes shall be made with UL listed pressure type connectors rated at 600 volts and 105 degrees C. Connector body shall consist of a cone-shaped, expandable, square-edged, coil-spring insert, insulated with a color-coded, self-extinguishing nylon shell with two wings placed opposite to each other to serve as a "built-in" wrench. Shell shall be molded of one piece. Connectors shall be IDEAL INDUSTRIES "Wing-Nut" or BUCHANNAN "B-CAP", 3M "SCOTCH-LOK" connectors or equal. Wire #8 and larger shall be joined or terminated with solderless pressure connectors properly taped in layers to form a moisture-tight joint.

PART 3 - EXECUTION

3.1 CONDUCTOR INSTALLATION, GENERAL

- A. Conductors shall be continuous from outlet to outlet, and no splices shall be made except within outlet or junction boxes. Junction boxes shall be provided where required. Home runs may be combined in one conduit, provided all connections are in accordance with NEC requirements and the maximum unbalanced current in the neutral does not exceed the capacity of the conductor. All parallel feeder runs shall be laid out and cut to exact same lengths before pulling into conduits to insure load balance. No additional trimming of parallel conductors will be accepted. Conductors #8 and smaller shall be pulled by hand and without aid of block and tackle or other mechanical device. Only approved equipment for pulling conductors shall be used for #6 and larger conductors. Only approved pulling compounds which will in no way damage the insulation on the conductors or hasten its aging may be used to facilitate pulling of wire into conduit. Circuiting shown shall be followed unless specific changes are approved by the Engineer.
- B. Where several feeders pass through a common pull box or junction box, the feeders shall be tagged to indicate clearly their electrical characteristics, circuit number, and panel designation. This same information shall be permanently marked on cover of the box.
- C. All conductors shall be in conduit unless otherwise indicated or allowed.

- D. All conductors and cables shall be labeled.

3.2 ALUMINUM CONDUCTORS INSTALLATION

- A. If at the option of the Contractor, aluminum wire and cable is selected, conduits and boxes shall be increased in size to accommodate increased wire sizes. Contractor shall use particular care in making up joints and terminations. Surface oxides shall be removed by cleaning with a wire brush or emery cloth. Oxide-inhibiting joint compound shall be used on conductors and UL listed solid aluminum connectors shall be used for connecting aluminum to aluminum. Where connecting aluminum to copper, connectors specifically designed for this purpose shall be used. If aluminum conductors are used for branch wiring, panelboard branch circuit load connectors as well as equipment and device terminals shall be specifically designed for use with aluminum conductors. If aluminum conductors are used for feeders, panelboard main connections and dry type transformer connections as well as main switchboard branch circuit connections shall be made by attaching a compression lug to the conductor with a high pressure, hand or hydraulic tool, with dies to match conductors and lug size, all designed to produce a cold flow bonded joint. Terminations under set-screw lugs in panelboards, disconnect switches, et., shall be made with BURNDY "Hyplug" plug type compression sleeve compression connectors. Bolt stud connections shall be made with one hole spade compression lugs. The use of wing-nuts and aluminum conductors terminating under set screw type connections are disallowed. If the Contractor elects the use of aluminum wire and cable, he shall be responsible for providing panelboard, switchboard and equipment cabinets of sufficient size to accommodate the aluminum conductors and to allow adequate space for bending, training and terminating them.

END OF CONDUCTORS

SECTION 16230

WIRING DEVICES

PART 1 - GENERAL

- 1.1 Provide wiring devices complete with all necessary trim rings or wall plates as shown or as required.

PART 2 - PRODUCTS

- 2.1 Wiring devices shall be as manufactured by LEVITON, ARROW-HART, BRYANT, HUBBELL or PASS & SEYMOUR. All wiring devices provided on this project shall be by the same manufacturer and shall be "specification grade".
- A. Local switches shall be single pole, double pole, three way and four way as shown on the drawings, black plastic cup with red plastic cover and ivory plastic handle, back or side wired, 20 ampere, 120-277 volts.
 - B. Duplex convenience receptacles shall be ivory plastic, 20 ampere, 125 volts, 2 pole, 3 wire NEMA and ASA Standard, grounding type.
 - C. Weatherproof receptacles shall be in cast metal box with gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening. Caps shall be provided with a spring-hinged flap. Receptacle shall be UL listed for use in "wet locations."
 - D. Ground fault circuit interrupting receptacles shall conform to NEC, shall be UL listed, ivory plastic, shall have a "push-to-test" button and visible indication of a tripped condition, and shall detect a current imbalance in device or equipment plugged-in of approximately 5 milliamperes and trip out under that condition.
 - E. Isolated grounding duplex receptacles shall be orange plastic, 20A, 125 volts, 3 pole, 3 wire type.
 - F. Special devices shall be as shown on drawings.
 - G. Device plates on unfinished walls and on fittings, shall be zinc-coated sheet steel having rounded or beveled edges. On finished walls, plates shall be satin finished type 302, Alloy 18-8 stainless steel with beveled edges. Plates shall be of one piece type to suit device or devices covered. Sectional plates will not be permitted. Junction boxes in finished areas shall have blank satin finish stainless steel plates as specified above. Telephone outlets in finished areas shall have satin finish stainless steel plates, as specified above, with single bushed hole in center. Plates on finished walls shall be nylon or lexan. Plates shall be same color as receptacle or toggle switch with which they are mounted. Screws shall be machine-type with countersunk heads in color to match finish of plate.

PART 3 - EXECUTION

3.1 Devices shall be installed in a rigid manner in outlet boxes. Device plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch.

3.2 GROUND-FAULT RECEPTACLE TEST

- A. Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

END OF WIRING DEVICES

SECTION 16250
SAFETY SWITCHES

PART 1 - GENERAL

- 1.1 Provide safety switches wherever shown and whenever required whether specifically shown or not.

PART 2 - PRODUCTS

2.1 SWITCHES

- A. Safety switches shall be rated at 600 or 240 volts as required for voltage of system with number of poles and current rating as indicated. Switches shall be fused or non-fused type as indicated, NEMA type GD or HD as required, with full cover interlocks and quick-make, quick-break mechanism.
- B. All fused switches shall be provided complete with fuses and shall have horsepower ratings when serving motor loads.

2.2 FUSES

- A. Fuses rated over 600 amperes shall be U.L. Class "L" fuses, and shall have a minimum time delay of 10 seconds at 500% rating. They shall be Littelfuse Type KLP-C time delay fuses or approved equal. All fuses 600 amperes and below shall be true dual-element time delay fuses with separate spring-loaded thermal overload elements in all ampere ratings. All ampere ratings shall be designed to open at 400 degrees Fahrenheit or less when subjected to a non-load oven test. RK-1 fuses shall be Littelfuse fuses, type LLN-RK or LLS-RK. RK-5 fuses shall be Littelfuse "Slo-Blo" fuses, type FLN-R or FLS-R. Fuses shall be sized as indicated on the drawings or as required by the equipment provided, whichever provides maximum protection.

PART 3 - EXECUTION

- 3.1 Switches shall be securely mounted to wall, structure or equipment. Provide miscellaneous accessories for mounting switches, including steel angles or channels where required.
- 3.2 Spare fuses. At the completion of the project the contractor shall deliver to the Owner (and obtain receipt for) spare fuses of each size and type equal to 20 percent of the number installed but not less than 3 or more than 9 of any size and type.

END OF SAFETY SWITCHES

SECTION 16310

PANELBOARDS

PART 1 - GENERAL

1.1 PANELBOARDS

- A. Panelboards shall be provided with number and size of mains and branch circuits as shown on drawings, shall be mounted as indicated and shall have incoming lugs arranged to receive the conductors shown. Panelboards shall conform to latest UL and NEMA standards and shall bear UL labels.

PART 2 - PRODUCTS

2.1 PANELBOARDS

- A. Panelboards shall be dead-front, circuit breaker type equipped with single, double, or three pole thermalmagnetic quick-make, quick-break trip-free on overload or short circuit alternating current circuit breakers with trip ratings and frame size as shown on the drawings.
- B. Main and branch circuit breakers shall provide inverse time delayed tripping on overloads and instantaneous tripping on short circuits. Trip indication shall be clearly shown by the breaker handle taking position between ON and OFF when the breaker is tripped. Double and three pole breakers shall be common trip type. HACR type circuit breakers shall be provided for all circuits serving mechanical equipment.
- C. Bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two to three-pole breakers can be installed at any location. All current-carrying parts of the bus assembly shall be plated.
- D. Sub-feed breakers are acceptable, however, if used must be clearly labeled on front panel and on interior of panel enclosure with machine engraved label mechanically attached.
- E. Where a "space, space-only, or provision" is indicated on the drawings or elsewhere, the "space, space-only, or provision" shall be "fully equipped" and ready for the direct insertion of a circuit breaker. Additional hardware, bus extension kits, strap kits, and so forth shall not be required in order to properly add a circuit breaker to a designated "space".
- F. Each panelboard shall be provided with a hinged cover with a flush latch and lock with two keys and keyed the same as all other panelboards.
- G. Each panel shall be equipped with typewritten directory card, card holder, transparent protection and complete identifying data on inside of door. Each circuit shall be identified specifically with load and location spelled out on the directory, i.e. "lighting Rooms 204, 206, 208" - (not merely "lighting"). Room numbers shall match Owner's final signage designations, and not the numbers shown on contract drawings, as they are often different. Contractor shall update existing panel's directory card reflecting any changes made under this contract.

- H. Provide an isolated neutral bus for each panel for connection of both feeder and branch circuit neutral wires. Neutral bus shall have same current ratings as panel mains.
- I. Provide a separate equipment ground bus, bonded to the steel cabinet for each panel for connection of all ground wires and mark with a green stripe along the front of the bus. Equipment ground bus shall have same rating as panel mains.
- J. Provide a separate isolated equipment ground bus, insulated from the steel cabinet for each panel indicated for connection of all isolated ground wires. Isolated equipment ground bus shall have same rating as panel mains.
- K. Ground fault circuit interrupting breakers shall be sized as indicated, shall conform to NEC, shall be UL listed, shall have a "push-to-test" button and visible indication of a tripped condition, and shall detect a current imbalance of approximately 5 milliamperes.
- L. Circuit breakers shall have 100% AIC rating, unless stated otherwise on drawings.
- M. Panelboards shall be equal to SQUARE-D, Type NQOD, NF, or I-LINE (HCN, HCM, HCP, HCW, HCWM, HCP-SU, HCR-U), or equal products by Cutler Hammer, Siemens, or G.E.

PART 3 - EXECUTION

3.1 PANELBOARDS

- A. Panelboards shall be so mounted that operating handle of top breaker is not more than 78" above the floor. Load on each panel shall be divided as evenly as possible between the phases in the panel.
- B. If at the option of the contractor, aluminum wire or cable is used and the corresponding conduit size was changed, it is the responsibility of the contractor to select a proper panelboard backcans to accommodate new conduit size and to provide adequate space for training and terminating the aluminum conductors.

END OF PANELBOARDS

SECTION 16320

SWITCHBOARD

PART 1 - GENERAL

- 1.1 Provide switchboards with the number and size of branch circuits and with the arrangement and capacity of bus and incoming service as shown. Switchboard shall conform to latest UL and NEMA standards and shall bear UL labels.

PART 2 - PRODUCTS

2.1 SWITCHBOARD

- A. Switchboard shall be equal to SQUARE-D, power style, type QMB, or I-line. Switchboard shall be a free standing, dead front, totally enclosed. The switchboard shall be designed and manufactured to be completely front accessible and conform to the requirements of a NEMA Class I switchboard.
- B. Enclosure: The base frame to be constructed of code gauge formed steel angles, channels and back plate welded together. The frame enclosure top and side plates shall be flat and screw removable. The front closure members shall be screw removable panels or hinged doors. All front closure members shall be formed with rolled edges. The entire unit shall be mechanically rigid. Louvers shall be furnished as required for proper ventilation. The switchboard shall have a die-formed base piece welded to the structure. It shall be of sufficient strength to support the entire switchboard for lifting by a fork truck and moving on rollers. Four base mounting holes shall be furnished in the base through which 1/2" lag bolts shall be used for securely mounting the switchboard in place. Two lifting eye bolts shall be furnished and installed through switchboard top plates and connected to the frame work to support the total weight of the entire switchboard.
- C. Finish: After fabrication and before assembly, the switchboard welded framework and all associated enclosure parts shall be thoroughly cleaned. The switchboard finish shall consist of a phosphate rust inhibiting primer and a finish coat of alkyd base gray baked enamel.
- D. Buss: All internal conductors shall be plated aluminum bus bars of sufficient cross sectional area to carry the rated ampere load and not exceed the maximum heat rise above ambient temperature as specified by Underwriter's Laboratories and NEMA. Bus bar joints and connections shall be bolted with hardened steel bolts and Belleville Pressure type washers.
- E. Current transformer compartment; the switchboard shall contain a current transformer compartment approved for use by utility company for installation and operation of current and potential transformers. Contractor shall verify and execute all coordination efforts necessary for successful installation of current and potential transformers and metering equipment.
- F. Main Circuit Breaker: The main circuit breaker shall be equal to Square D type "SE", fixed mounted, manually operated, 100% rated with two-step stored energy mechanism, local ammeter, local trip indicators for overload, short circuit and ground fault. The main

circuit breaker shall be equipped with a trip unit that has long time, short time, instantaneous and ground fault settings.

- G. Distribution section shall consist of a molded-case thermal-magnetic circuit breaker assembly group mounted in a panel-type construction. Circuit breakers shall be rated as indicated on drawings. Tripping mechanisms shall consist of thermal and magnetic trip elements on each pole. Trip indication shall be provided on the breaker handle. Means shall be provided for padlocking handle in the "ON" and "OFF" position.
- H. Where a "space" is indicated on the drawings or elsewhere, the space shall be "fully equipped" and ready for the direct insertion of a circuit breaker. Additional hardware, bus extension kits, strap kits, and so forth shall not be required in order to properly add a circuit breaker to a designated "space".
- I. Metering: The switchboard shall have a Square D or equal digital powermeter #PM820 capable of reading current, voltage, power energy, demand and frequency.
- J. Circuit breakers shall have 100% AIC rating, unless stated otherwise on drawings.

PART 3 - EXECUTION

3.1 SWITCHBOARD

- A. Secure switchboard in place with lag screws in expansion shields set in concrete pad. Provide 2 1/2" high concrete housekeeping pad above equipment room floor on which to mount and secure the switchboard. Pad shall be 2 1/2 inches larger all around than the switchboard base structure.

- 3.2 TESTING: After assembly and before shipment, the entire switchboard shall be factory tested for proper electrical coordination and continuity. The testing shall be in accordance with the latest applicable standards of IEEE, ANSI and NEMA.

END OF SWITCHBOARD

SECTION 16330
TRANSFORMERS

PART 1 - GENERAL

- 1.1 Provide dry-type transformers as shown to step the main incoming service voltage down to the utilization voltage required for lighting, small motor and other loads as shown.

PART 2 - PRODUCTS

2.1 TRANSFORMERS

- A. Transformers shall be NEMA TP-1, minimum, self-cooled, dry type, single or three phase as indicated. Primary and secondary voltages, and KVA ratings shall be as indicated. Insulation shall be 600 volt class "H", except transformers rated 112.5 KVA and above shall have 600 volt class "F" (155°) insulation. Transformers shall be rated for 115 degrees centigrade rise. Transformer shall be quiet type with noise level 3 dB below NEMA ST-20. Transformer shall have two 2 1/2 percent taps above and four 2 1/2 percent taps below normal rated voltage.

PART 3 - EXECUTION

3.1 TRANSFORMERS

- A. Mount transformers on suitable vibration isolating foundations or support brackets and provide short lengths of flexible metallic conduit in all connections thereto to prevent transmission of transformer hum to building structure and to conduit systems. Provide 3-1/2" thick concrete housekeeping pad on which to place all floor mounted transformers. The pad shall extend a minimum of 3" beyond the transformer on all sides. Transformers rated through 45 KVA shall be located at least 4" away from walls or obstructions to allow free circulation of air through the ventilation openings. For units above 45 KVA minimum spacing shall be 6 inches.

3.2 TRANSFORMER TESTS

- A. Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

END OF TRANSFORMERS

SECTION 16410
LIGHTING FIXTURES

PART 1 - GENERAL

1.1 LIGHTING FIXTURES

- A. Fixtures shall be UL approved, listed and labeled for the particular installation. Lighting fixtures shall be provided complete with lamps, mounting hardware, accessories, canopies, necessary guards, straps, supports or hangers and other miscellaneous materials and devices to assure satisfactory installation and desired function where installed and shall be approved before installation.

PART 2 - PRODUCTS

2.1 FIXTURES

- A. Fixtures shall be as indicated as detailed on drawings. Cuts and descriptions of all fixtures shall be submitted for approval before ordering. When requested, samples of the fixtures, shall be provided.

2.2 LAMPS

- A. Provide as indicated on fixture details.

2.3 BALLASTS

- A. Fluorescent ballasts shall be ETL and UL approved and shall be energy saving electronic type compatible with lamps specified. Fixtures shall be designed for use with these electronic ballasts and shall have thermal characteristics that will minimize operation of ballast over-heat devices under all normally expected operation conditions. Ballasts shall have a Class A sound rating.
- B. Ballasts which are not quiet and hum-free will be rejected and shall be replaced by the Contractor at no additional cost to Owner.
- C. Ballasts in unconditioned spaces or outdoors shall be rated for operation in high or low temperature environments.

2.4 FLUORESCENT EMERGENCY LIGHTING UNITS

- A. Each unit shall consist of an automatic power failure device, test switch operable from outside of the fixture, pilot light visible from outside the fixture, and fully automatic solid-state charger in a self-contained power pack. Charger shall be either trickle, float, constant current or constant potential type, or a combination of these. Battery shall be sealed electrolyte type with capacity as required to supply power to two lamps for 90 minutes at a minimum of 25 percent of the lamps rated lumen output. Battery shall operate unattended and require no maintenance, including no additional water, for a period of not less than 5 years. Emergency ballasts which are provided with fixtures containing solid-state ballasts shall be suitable for use with solid-state ballasts.

PART 3 - EXECUTION

3.1 LIGHTING FIXTURES

- A. Locations of fixtures in ceiling shall be in accordance with the reflected ceiling plan. Contractor's attention is directed to coordinating with lighting fixtures and mechanical equipment in all spaces. Where recessed lighting fixtures are indicated, this Contractor shall be responsible for coordinating the type fixtures with the actual ceiling being installed. This shall include all changes resulting from substitute items, change orders, etc.
- B. All surface mounted fluorescent lighting fixtures shall be mounted independent of ceiling construction. All fluorescent lighting fixtures mounted in or on plaster ceiling shall also be mounted independent of ceiling construction. Where recessed fluorescent lighting fixtures occur in lay-in tile or concealed spline ceiling the electrical contractor shall have the ceiling contractor install additional supporting hangers where fixtures occur.
- C. No fixtures shall be hung with zip-clips.
- D. Recessed and flush mounted fixtures shall be of type which can be relamped from bottom except as otherwise specified. Trim for exposed surface or flush mounted fixture shall be as detailed for that fixture.
- E. Flush or recessed fixtures shall be provided with separate junction boxes, and fixtures shall be readily removable for access to the boxes or ceiling access panels shall be provided.
- F. Pendant mounted fixtures and devices shall be supported with swivel type hanger to ensure plumb installation.

END OF LIGHTING FIXTURES

SECTION 16470

TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) (SURGE PROTECTIVE DEVICES)

PART 1 - GENERAL

- 1.1 The work required under this division shall include all materials, labor and auxiliaries required to install complete surge suppression for the protection of building electrical and electronic systems from the effects of line and electromagnetic induced transient voltage surges and coupled lightning discharged transients as indicated on drawings and as specified in this section.
- 1.2 STANDARDS
 - A. The following standards and publications referenced in various parts of this specification shall apply.
 - 1. UL 1449 - Second Edition; effective February 16, 1998 Standard for Safety for Transient Voltage Surge Suppressors.
 - 2. ANSI/IEEE C62.41, Recommended Practice for Surge Voltages in Low Voltage AC Power Circuits.
 - 3. NEMA LS-1, Specification Format for Low Voltage AC Surge Protective Devices (1000 volts or less).
 - 4. CSA - C22.2 and NOM Approvals for TVSS.
- 1.3 SUBMITTALS
 - A. Contractor shall provide submittal data as defined in Section [16010] [26 05 00] "ELECTRICAL GENERAL PROVISIONS", and as required in the Division [1] [01] section governing submittal requirements. Also, Contractor shall provide NEMA LS-1 document for submittal to the Engineer.
- 1.4 QUALIFICATIONS
 - A. All surge protective devices shall be manufactured by a single ISO-9001 registered company normally engaged in the design, development and manufacture of such devices for electrical and electronic system equipment protection. The said firm shall offer a ten-year (10) warranty for its hard-wired surge protective devices.
 - B. The surge protective device manufacturer shall offer at no cost technical assistance through support from factory representatives and local authorized distributors and maintain a 24-hour toll free technical support hotline.
 - C. Equipment certification: Items shall be "Listed" by Underwriters Laboratories, Inc. and shall exhibit the UL Listing Mark for the category "Transient Voltage Surge Suppressors" or TVSS. UL Listing Card under category TVSS shall be provided to confirm compliance to UL1449 Second Edition Standard and assigned Suppressed Voltage Ratings.

- D. Surge Protective Devices shall be installed and located in accordance with the requirements of all applicable National Fire Protection Association (NFPA) codes. The device shall be installed on the load-side of the main service disconnect per the scope of UL 1449 Standard for Safety for Transient Voltage Surge Suppressors.
- E. All surge protective devices shall be warranted to be free from defects in materials and workmanship under normal use in accordance with the instructions provided for a period of ten (10) years.
- F. Any surge protective device that exhibits evidence of failure or incorrect operation during the warranty period shall be repaired or replaced by the manufacturer.
- G. Manufacturers shall provide third party nationally recognized national laboratory verification of performance data including Maximum Surge Current testing.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All Surge Protectors shall be designed for the specific type and voltage of the electrical service as indicated on the drawings, and provide suppression for all phases (L-N), all phases (L-G), and (N-G).
- B. All Surge Protectors shall be of a parallel-operated hybrid circuit design and include full cycle tracking clamping capability.
- C. All Surge Protectors shall be designed to withstand a maximum continuous operating voltage (MCOV) rating of not less than 115% of the system rms line voltage to which they are connected.
- D. All Surge Protectors shall provide minimum -30dB noise attenuation across the 5k - 100MHz frequency spectrum.
- E. All Surge Protectors shall contain internal safety fusing to disconnect surge protective components from the electrical source of supply in the event of SPD failure in order to prevent catastrophic failure.
- F. All Surge Protectors shall not allow follow-current or "crow-bar" components, which may disconnect power to connected equipment during surge diversion.
- G. All Surge Protectors shall be UL 1449, 2nd Edition Listed and shall be approved for the location in which they are installed.
- H. All Surge Protectors shall have operating temperature range of -10 to +60 degrees C.
- I. Loss of Protection Diagnostic lights for each phase shall be provided. In addition, separate visual and audible fault indication shall be provided. Provision for remote monitoring shall be provided via a dry contact.
- J. Surge protection devices shall be provided in minimum NEMA 12 enclosures.

- 2.2 REPLACEABLE MODULAR SURGE PROTECTOR MINIMUM RATINGS: (Main Service)
- A. Maximum Surge Current (8x20 us waveform): 200kA (L-N), 200kA (L-G), 200kA (N-G)
UL 1449 SVR: 400V peak (120V), 800V peak (277V)
- 2.3 REPLACEABLE MODULAR SURGE PROTECTOR MINIMUM RATINGS: (Distribution Panels)
- A. Maximum Surge Current (8x20 us waveform): 60kA (L-N), 60kA (L-G), 60kA (N-G) UL
1449 SVR: 400V peak (120V), 800V peak (277V)
- 2.4 ACCEPTABLE MANUFACTURERS
- A. EFI Electronics
- B. LEA International
- C. Current Technology

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Surge Protectors shall be installed as close as practical to the electrical panel or switchboard to be protected. The SPD shall be close coupled to the equipment in a position near the equipment neutral bus bar or positioned so that the overall lead length is as short as possible.
- B. The Surge Protector shall be installed in a manner consistent with proper and acceptable industry wiring practice. SPD connection leads shall be as short and straight as possible while avoiding sharp bends.
- C. Surge Protectors provided with terminals shall be wired with largest stranded conductor permitted within rating of lugs. At least 8 AWG conductor shall be used.
- D. The Surge Protector shall be installed with a means for disconnecting the device for servicing via a dedicated three-pole circuit breaker, size as indicated on the drawings, unless manufacturer's recommendations differ.

END OF TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) (SURGE PROTECTIVE DEVICES)

SECTION 16710
TELEPHONE CONDUIT SYSTEMS

PART 1 - GENERAL

- 1.1 Provide complete system of empty conduit, outlets, fittings, appurtenances, equipment backboards and equipment cabinets for installation of the telephone and other communication systems.

PART 2 - PRODUCTS

- 2.1 Provide outlets, fittings and minimum 3/4" conduit in all runs in accordance with Section entitled "RACEWAY, FITTINGS AND BOXES".

- A. Provide 3/4" thick plywood backboards with (2) coats of insulating fire retardant varnish, secured to walls where shown for mounting of telephone terminals and equipment.

PART 3 - EXECUTION

- 3.1 Provide nylon pull string in each conduit run.

- A. Install telephone conduits, outlet boxes, cabinets and backboards, including point of service in accordance with requirements of local telephone company.

3.2 GROUNDING

- A. Provide grounding conductor in conduit from main building ground to the main telephone backboard and all remote located telephone backboard.

END OF TELEPHONE CONDUIT SYSTEMS

SECTION 16721

ADDRESSABLE FIRE DETECTION & ALARM SYSTEM

PART 1 – GENERAL

1.1 SCOPE

- A. The work includes modifying existing interior fire alarm system devices, that shall be low voltage and modular and be in full compliance with all applicable codes and standards. The features and capacities described in this specification are required as a minimum for this project and shall be furnished by the successful contractor.
- B. The control panel is a Simplex Model 4100U addressable, analog detecting, low voltage and modular, with digital communication techniques, in full compliance with all applicable codes and standards. The features and capacities described in this specification are required as a minimum for this project and shall be furnished by the successful contractor.
- C. The system shall be in full compliance with applicable NFPA 72-2007 Standards and the 2006 Virginia Uniform Statewide Building Code.
- D. The system shall include all required hardware, raceways, interconnecting wiring and software to accomplish the requirements of this specification, the contract drawings, and applicable local, state, and federal code, whether or not specifically itemized herein.
- E. All additional equipment required shall be new and the latest state of the art products of a system compatible manufacturer engaged in the manufacturing and sale of analog fire detection devices for over five years.
- F. The system as specified shall be supplied, installed, tested, and approved by the authority having jurisdiction (AHJ), and turned over to the owner in an operational condition.
- G. In the interest of job coordination and responsibilities the installing contractor shall contract with a single supplier for fire alarm equipment, engineering, programming, and final connections.
- H. The locations and types of fire alarm system devices to include alarm initiating appliances, alarm notification appliances, control and trouble signaling equipment, and the location of major components shall not be altered by the Contractor without prior written approval by the Engineer and the Building Official. Changes to the design depicted within the Construction Documents shall be considered substitutions in accord with the General Conditions and are to be documented by Change Order.

1.2 RELATED WORK

- A. Division 1 Bidding Requirements and Conditions Of The Contract.
- B. Division 16 Section 16010 Electrical General Provisions.
- C. Division 13 Section 13930 Wet Pipe Sprinkler Systems with Fire Pump.
- D. Division 15 Energy Monitoring & Control (HVAC).

1.3 STANDARDS & CODES

- A. The publications listed below form a part of this publication to the extent referenced. The publications are referenced in the text by the basic designation only. The latest version of each listed publication shall be used as a guide unless the authority having jurisdiction has adopted an earlier version.
- B. Factory Mutual (FM)
 - 1. FM AG Approval Guide.
- C. National Fire Protection Association (NFPA)
 - 1. NFPA 13 – 2007 Standard For The Installation of Sprinkler Systems.
 - 2. NFPA 70 - 2005 National Electrical Code.
 - 3. NFPA 72 - 2007 National Fire Alarm Code.
 - 4. NFPA 90A Standard For The Installation of Air Conditioning And Ventilating Systems.
 - 5. NFPA 101 Life Safety Code.
 - 6. NFPA 170 Standard Fire Safety and Hazmat Symbols
- D. Underwriters' Laboratories, Inc. (UL) Appropriate “UL” equipment standards.
 - 1. “UL” 864 Control Panels.
 - 2. “UL” 268 Smoke Detectors.
 - 3. “UL” 268A Smoke Detectors (HVAC).
 - 4. “UL” 1076 Security.
 - 5. “UL” 1971, Standard for Visual Signaling Appliances.
- E. Building Codes
 - 1. Virginia Uniform Statewide Building Code 2006
 - 2. State and Local Building Codes as adopted and/or amended by The Authority Having Jurisdiction.
 - 3. ADA, and/or State and local equivalency standards as adopted by The Authority Having Jurisdiction.
 - 4. ADAAG Americans with Disabilities Act Accessibility Guidelines

1.4 QUALIFICATIONS OF INSTALLERS

- A. Before commencing work, submit data showing that the contractor has successfully installed fire alarm systems of the same scope, type and design as specified.
- B. The contractor shall submit copies of all required Licenses and Bonds as required in the State having jurisdiction within the submittals.
- C. The contractor shall employ on staff a minimum of one NICET level II technician and provide proof of such employment within the submittals.

1.5 MANUFACTURER'S REPRESENTATIVE

- A. Provide the services of a factory trained and certified representative or technician, experienced in the installation and operation, maintenance and service of the type of system provided. The representative shall be licensed in the State if required by law. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the owner's personnel in the system operation, maintenance and programming. Provide copies within the submittals of all applicable certifications of training only from technicians that will actually be assigned and deployed to this project. Engineer may at any time visit site to ensure the technicians on site are the ones that were submitted on.
- B. The contractor shall include the following information in the equipment submittal:
 - 1. Power calculations. Battery capacity calculations. Battery size shall be a minimum of 125% of the calculated requirement.
 - 2. Supervisory power requirements for all equipment.
 - 3. Alarm power requirements for all equipment.
 - 4. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst-case condition plus 25% spare capacity.
 - 5. Voltage drop calculations for wiring runs demonstrating worst-case condition.
 - 6. NAC circuit design shall incorporate a 15% spare capacity for future expansion.
 - 7. Complete manufacturers catalog data including supervisory power usage, alarm power usage, physical dimensions, finish, and mounting requirements. Data sheets shall include UL file numbers for all products. This may be in a tabular form or hand annotated on the cut sheets. DO NOT SUBMIT COPIES OF UL FILE NUMBERS.
 - 8. Complete drawings covering the following shall be submitted by the contractor for the proposed system:
 - a) Floor plans in a CAD compatible format showing all equipment and raceways, marked for size, conductor count with type and size, showing

the percentage of allowable National Electric Code fill used. Wiring for the fire alarm system is not shown on the contract drawings. The contractor shall lay out the wiring arrangement between the system components in the most convenient form for their installation and show it on the floor plans. At the conclusion of the project, the contractor shall correct and modify this wiring layout to conform with the actual runs and connections for inclusion into the final set of record drawings.

- b) A complete fire alarm job specific riser diagram showing all addressable, notification, communication, shutdown, and power circuits and their relative service areas in the building that are attached to the fire alarm system. Include all candela ratings, device addresses, and room numbers.
- c) Typical job specific wiring diagrams for all field devices used in the proposed system. Diagrams shall be sized and laid out so that individual wire detail can be determined.
- d) A job specific wiring diagram of the fire alarm control panel and all associated control panels (i.e. transponders, NAC extender panels, communicators, remote annunciators, etc.)
- e) Provide a fire alarm system function matrix as referenced by NFPA 72, Figure A-7-5.2.2 (9). Matrix shall illustrate alarm input/output events in association with initiation devices. Matrix summary shall include system supervisory and trouble output functions. Include any and all departures, exceptions, variances or substitutions from these specifications and/or drawings at time of bid.

9. Incomplete submittals may be returned without review.

1.6 SYSTEM REQUIREMENTS

- A. The system shall be a complete, electrically supervised fire detection and notification system, microprocessor based operating system having the following; capabilities, features and capacities:
 - 1. Communication between network nodes, each supporting an interactive, self-standing, intelligent local control panel, with system wide displays.
 - 2. The local system shall provide status indicators and control switches for all of the following functions:
 - a) Audible and visual notification alarm circuit zone control.
 - b) Status indicators for sprinkling system water-flow and valve supervisory devices.
 - c) Any additional status or control functions as indicated on the drawings, including but not limited to; emergency generator functions, fire pump functions, door unlocking and security with bypass capabilities.

3. Each intelligent addressable device or conventional zone on the system shall be displayed at the main fire alarm control panel and any local fire alarm control panel by a unique alphanumeric label identifying its location.
4. All control panels and transponders within the system that require a 120 VAC connection shall be provided with an AC hard-wired transient voltage surge suppressor that conforms to UL and IEEE C62.41B and have the following characteristics.

Connection Method: Hardwire parallel connection

Continuous Current: Unlimited (Parallel Installation)

<5nSec Installed, <1nSec Component

Response Time: Level

MCOV: 130 VRMS/185 VPK

Operating Frequency: 50/60Hz

AC Protection Modes: L - N, L - G, N - G

Service Voltage: 110 / 125 VAC

Diagnostics: Indicator Light

EMI/RFI Noise Filtering: Yes

Max Surge Current: 22,500 Amps

Max Energy Dissipation: 190 Joules

Surpressed Voltage Rating: 600V

Operating Temperature

Range: -40 degrees C. to +85 degrees C.

Be certain that all units are grounded properly and connected to a good source of building ground.

1.7 SYSTEM OPERATION

- A. Activation of any system fire, security, supervisory, trouble, or status initiating device shall cause the following actions and indications at all alphanumeric displays in the system.
- B. Fire Alarm Condition:
 1. Sound an audible alarm and display a custom screen/message defining the building in alarm and the specific alarm point initiating the alarm.
 2. Log to the system history archives all activity pertaining to the alarm condition.
 3. Sound the ANSI 117-1 signal with synchronized audibles and synchronized strobes throughout the facility.
 4. Audible signals shall be silenced from the fire alarm control panel by an alarm silence switch. Visual signals shall be programmable to flash until system reset or alarm silencing, as required.
 5. A signal dedicated to sprinkler system water flow alarm shall not be silenced while the sprinkler system is flowing at a rate of flow equal to a single head.

6. The alarm information shall be displayed on an existing system display annunciator located where shown on drawings.
 7. HVAC shut down shall be accomplished by system operated duct detectors as per local requirements.
- C. Supervisory Condition:
1. The supervisory information shall be displayed on an existing system display annunciator located where shown on drawings.
 2. Activate supervisory audible and dedicated visual signal.
 3. Audible signals shall be silenced from the control panel by the supervisory acknowledge switch.
 4. Record within system history the initiating device and time of occurrence of the event.
- D. Trouble Condition:
1. The trouble information shall be displayed on an existing system display annunciator located where shown on drawings.
 2. Activate trouble audible and visual signals at the control panel and as indicated on the drawings.
 3. Audible signals shall be silenced from the fire alarm control panel by a trouble acknowledge switch.
 4. Record within system history, the occurrence of the event, the time of occurrence and the device initiating the event.

PART 2 – PRODUCT

2.1 CONTROL PANEL

- A. The fire alarm control panel is an existing Simplex Model 4100U.
- B. Control panel shall be listed under UL classification UOJZ as a proprietary protected premises control unit for A, M, WF, and SS service.

2.2 POWER SUPPLY, BATTERY, & BATTERY CHARGER - EXISTING

2.3 SYSTEM ENCLOSURES - EXISTING

2.4 REMOTE ANNUNCIATORS - EXISTING

2.5 DIGITAL ALARM COMMUNICATION TRANSMITTER (DACT) - EXISTING

2.6 INTELLIGENT INITIATION DEVICES

- A. The smoke detector shall be an intelligent digital photoelectric detector with a programmable heat detector. Detectors shall be listed for use as open area protective coverage, in duct installation and duct sampling assembly installation and shall be insensitive to air velocity changes. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds. The intelligent smoke detector shall be capable of providing three distinct outputs from the control panel. The system controlled output functions shall be from an individual or unique input of smoke obscuration, a thermal condition or a combination of obscuration and thermal conditions. The detector shall be designed to eliminate calibration errors associated with field cleaning of the chamber. The detector shall support the use of a relay and LED remote indicator at the same time.
- B. Thermal Detectors shall be rated at 135 degrees fixed temperature and 15 degrees per minute rate of rise. Detectors shall be constructed to compensate for the thermal lag inherent in conventional type detectors due to the thermal mass, and alarm at the set point of 135 degrees Fahrenheit. The choice of alarm reporting as a fixed temperature detector or a combination of fixed and rate of rise shall be made in system software and be changeable at any time without the necessity of hardware replacement. The detectors furnished shall have a listed spacing for coverage up to 2,500 square feet and shall be installed according to the requirements of NFPA 72 for open area coverage.
- C. The duct smoke detector shall be an intelligent digital photoelectric detector. Detectors shall be listed for use as open area protective coverage, in duct installation and sampling assembly installation and shall be insensitive to air velocity changes. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds. The detector shall be mounted in a duct detector housing listed for that purpose. The duct detector shall support the use of a remote test switch, relay or LED remote indicator. Provide remote indicator lamps or LED's in clearly visible locations for duct detector units that are hidden from view while standing on the floor. Detectors shall also be provided with enough auxiliary relay contacts to interface to any peripheral equipment as shown on contract drawings. Relays shall be capable of activating either by following the state of the associated detector or be globally controllable from any point in the system. The duct detector shall be supplied with sampling tubes that are specifically sized to the width of the duct at the location where the unit is to be installed. In no case should a larger sampling tube that is meant for larger ducts be cut down to accommodate a smaller duct where a smaller standard size tube is available. Where duct detectors are exposed to the weather provide a weatherproof enclosure. Duct detector units shall be provided and connected under this division and mounted by the Division 13 contractor.
- D. Detector bases shall be low profile twist lock type with screw clamp terminals and self-wiping contacts. Bases shall be installed on an industry standard, 4" square or octagonal electrical outlet box.
 - 1. Where selective localized control of electrical devices is required for system operation, furnish and install detector base with software programmed addressable relay integral to the base. The relay shall switch electrical loads within relay ratings, as indicated on the drawings. Operation of the addressable control circuit shall be independent of the number of detectors and relays on the circuit or the number in an alarm state. Relay bases shall be rated for resistive or inductive load (120VAC or 30VDC) 3 amps.

2. Where indicated on the drawings, furnish detector base with integral approved audible evacuation alarm signal having an output of 85db. The audible signal shall be individually addressable and software programmed for operation.
- E. Provide double action addressable manual stations where shown on the drawings, to be flush or surface mounted as required. Manual stations shall contain the intelligence for reporting address, identity, alarm and trouble to the fire alarm control panel. The manual station communications shall allow the station to provide alarm input to the system and alarm output from the system within less than four (4) seconds. The manual station shall be equipped with terminal strip and pressure style screw terminals for the connection of field wiring. Surface mounted stations where indicated on the drawings shall be mounted using a manufacturer's prescribed matching red enamel outlet box.
- F. Addressable Interface Devices shall be provided to monitor contacts for such items as water-flow, tamper, and PIV switches that are required to be connected to the fire alarm system. Provide the connection to these devices whether they are shown on the electrical contract drawings or not. These interface devices shall have single or dual contact monitoring capabilities. Where remote supervised relay is required the interface shall be equipped with a SPDT relay rated for 4 amps resistive and 3.5 amps inductive.

2.7 NOTIFICATION APPLIANCES

- A. The horn or horn/strobe appliance as indicated on the drawings shall be a synchronized temporal horn with a synchronized strobe light with multiple candela taps to meet the intended application. The strobe light taps shall be adjustable for 15, 30, 75, and 110 candela. The strobe shall flash at a rate between 1/3 and 3 flashes/second. The sound output shall be rated at a minimum of 95 dBA at 10 ft. when tested in an anechoic chamber. The appliance shall be red for wall mounted and white for ceiling mounted. Ceiling mounted appliances shall be rated for that application.
- B. The strobe only appliance as indicated on the drawings shall be a synchronized strobe light with multiple candela taps to meet the intended application. The strobe light taps shall be adjustable for 15, 30, 75, and 110 candela. The appliance shall be red for wall mounting and white for ceiling mounted. Ceiling mounted appliances shall be rated for that application.
- C. An alarm extender panel shall be provided where needed. The power supply shall be a minimum of 6 amps. The power supply shall contain four supervised notification circuits maximum of 3 amps each circuit. The power supply shall contain built-in synchronizing modules for strobes and audibles. There shall be a 3 amp filtered auxiliary power limited output. There shall be a minimum of 8 options as to the operations of the inputs and outputs.
- D. Sprinkler System Bell - On projects that require sprinkler system monitoring, provide a weatherproof bell mounted where shown on the contract drawings. Bell shall operate on panel notification circuit and alarm only when a sprinkler related alarm occurs. Provide with weatherproof backbox that matches the color of device. Provide device with standard 4" square mounting, 4" min bell, vibrating operation with minimum 75dB UL rating.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Perform work in accordance with the requirements of NFPA 70 and NFPA 72.
- B. Fasten equipment to structural members of building or metal supports attached to structure, or to concrete surfaces.
- C. All fire alarm cabling shall be supplied in conduit.

3.2 BOXES, ENCLOSURES AND WIRING DEVICES

- A. Boxes shall be installed plumb and firmly in position.
- B. Extension rings with blank covers shall be installed on junction boxes where required.
- C. Junction boxes served by concealed conduit shall be flush mounted.
- D. Upon initial installation, all wiring outlets, junction, pull and outlet boxes shall have dust covers installed. Dust covers shall not be removed until wiring installation when permanent dust covers or devices are installed.

3.3 CONDUCTORS

- A. Each conductor shall be identified as shown on the drawings at each with wire markers at terminal points. Attach permanent wire markers within 2 inches of the wire termination. Marker legends shall be visible.
- B. All wiring shall be supplied and installed in compliance with the requirements of the National Electric Code, NFPA 70, Article 760, and that of the manufacturer.
- C. Wiring for strobe and audible circuits shall be a minimum 14 AWG, signal line circuits shall be minimum 18 AWG.
- D. All splices shall be made using solderless connectors. All connectors shall be installed in conformance with the manufacturer recommendations.
- E. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.
- F. Permanently label or mark each conductor at both ends with permanent alphanumeric wire markers.
- G. A consistent color code for fire alarm system conductors shall be used throughout the installation.
- H. Wiring within sub panels shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.

3.4 DEVICES

- A. Relays and other devices to be mounted in auxiliary panels are to be securely fastened to avoid false indications and failures due to shock or vibration.
- B. Wiring within sub-panels shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.
- C. All devices and appliances shall be mounted to or in an approved electrical box.

3.5 FIELD QUALITY CONTROL

- A. Testing, general
 - 1. All Alarm Initiating Devices shall be observed and logged for correct zone and sensitivity. These devices and their bases shall be tagged with adhesive tags located in an area not visible when installed, showing the initials of the installing technician and date.
 - 2. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. Resistance, current and voltage readings shall be made as work progresses.
 - 3. A systematic record shall be maintained of all readings using schedules or charts of tests and measurements. Areas shall be provided on the logging form for readings, dates and witnesses.
 - 4. The acceptance inspector shall be notified before the start of the required tests. All items found at variance with the drawings or this specification during testing or inspection by the acceptance inspector shall be corrected.
 - 5. Test reports shall be delivered to the acceptance inspector as completed.
 - 6. The installing contractor shall make instruments, tools and labor required to conduct the system tests available.
 - 7. The following equipment shall be a minimum for conducting the tests:
 - a) Ladders and scaffolds as required to access all installed equipment.
 - b) Multimeter for reading voltage, current and resistance.
 - c) Two way radios, and flashlights.
 - d) A manufacturer recommended device for measuring airflow through air duct smoke detector sampling assemblies.
 - e) Decibel meter.
- B. In addition to the testing specified to be performed by the installing contractor, the installation shall be subject to test by the Engineer of Record and the AHJ.

3.6 ACCEPTANCE TESTING - ALL REQUIRED TESTING PER CHAPTER 10 OF NFPA 72-2007 SHALL BE PERFORMED

- A. The contractor shall be responsible for demonstrating the function of the system and verifying the correct operation of all system components, circuits, and programming.
- B. A program matrix shall be prepared by the installing contractor referencing each alarm input to every output function affected as a result of an alarm condition on that input.
- C. The installing contractor, prior to the final test shall prepare a complete listing of all device labels for alphanumeric annunciator displays.
- D. The Contractor shall be responsible for contacting the Regional Office of the State Fire Marshal to coordinate their witness of the below tests (at a minimum).
- E. The acceptance inspector shall use the system record drawings in combination with the documents specified during the testing procedure to verify operation as programmed. In conducting the acceptance test, the inspector may request demonstration of any or all input and output functions.
- F. The items tested shall include but not be limited to the following:
 - 1. System wiring shall be tested to show the following results and the system subsequence operation:
 - a) Open, Shorted or Grounded Circuits.
 - b) Primary and Battery power disconnected.
 - 2. System notification circuits and appliances operate as programmed. Audibility and Visual levels meet required standards.
 - 3. System shall demonstrate the correct messages at the FACP and Remote Annunciator.
 - 4. System off site reporting shall be verified for alarm, supervisory and trouble.
 - 5. System shall be tested for stand-by battery back up as outlined in this specification.

3.7 DOCUMENTATION

- A. System documentation shall be supplied to the owner and shall include but not be limited to the following:
 - 1. System record drawings and wiring details (4 copies) including one set of reproducible drawings, and a CD ROM with copies of the record drawings in DXF format for use in a CAD drafting program.
 - 2. System Operating, Installation and Maintenance Manuals (4 copies).
 - 3. System matrix showing input signals to output commands.

4. Provide a copy of the system program on a CD/DVD.
5. Warranty letter that details what is covered under the warranty and the start and end dates.
6. NFPA 72 record of completion form filed out in its entirety by the fire alarm contractor.

3.8 WARRANTY AND SERVICES

- A. The contractor shall warranty the entire system for electrical and mechanical failures for a period of one year. This warranty shall include all parts, labor, maintenance, and software upgrades. The warranty shall begin with the completion of the acceptance testing or when beneficial use to the owner is determined.
- B. The fire alarm system subcontractor or manufacturer shall offer for the owner's consideration at the time of system submittal a priced inspection, maintenance, testing, and repair contract in full compliance with the requirements of NFPA 72, broken out annually for a period of 3 years after the initial warranty period has expired. If applicable, include any and all optional levels of support ranging from minimum (i.e. time and materials) to complete turnkey coverage (i.e. 4 hour response time). Submittals that do not include this offering shall be considered incomplete and be returned without review.
- C. Any future system additions shall include a separate breakdown of both parts and labor. Labor breakdown must include anticipated number of technician hours necessary to complete the addition. Future submittals or cost proposals that do not include this information shall be considered incomplete and be returned without review.
- D. The contractor performing the contract services shall be qualified, factory trained, and certified in the service and maintenance of the system provided and listed to maintain ongoing certification of the completed system to the "UL" installed system listing.
- E. The installation contractor shall furnish training as follows:
 1. Training in the receipt, handling, and acknowledgment of alarms.
 2. Training in the system operation including manual control of output functions from the system control panel.
 3. The total training requirement shall be a minimum of 2 hours, but shall be sufficient to cover all items specified. The contractor shall provide two such training sessions.

END OF ADDRESSABLE FIRE DETECTION & ALARM SYSTEM

SECTION 16770

ACCESS CONTROL / VIDEO BADGING SYSTEM

PART 1 - GENERAL

1.1 NARRATIVE

- A. Provide access control for doors shown on contract drawings, provide readers and power supplies, and other accessories that will provide the customer with a complete system in accordance with the contract drawings.
- B. The system shall be a modular, networked access control system. The system shall allow for easy expansion and modification of inputs and outputs.
- C. The system control at the central computer location shall be under a single software program control, shall provide full integration of all components, and shall be alterable at any time, depending upon the facility requirements. Reconfiguration shall be accomplished online through system programming, without hardware changes.
- D. The software program shall be a true 32-bit, 3-tier client/server, ODBC compliant application based on Microsoft tools and standards. The software program shall operate in one of the following environments; Windows XP, 2000, or 2003 using the latest service packs.
- E. The database architecture shall utilize either Microsoft SQL Server 2000, SQL Server 7, or MSDE.
- F. The System shall require one master control file server station. Workstations licenses, if required at a later time, shall be able to be purchased and added without the changing of software or physical components of the system.
- G. Capacities in the control system shall be 64 readers, 25,000 card holders, unlimited alarm points, and unlimited relay outputs.
- H. The Glenns Campus shall contain the master control file server station, camera and card printer. The Warsaw Campus shall contain a workstation and camera connected to the network.

1.2 SUBMITTALS

- A. After project award, provide complete CAD generated 1/8" scale drawings detailing installation locations of equipment. Symbols used shall match those shown on the contract drawings.
- B. Provide detailed one-line drawings of systems. Each system drawing shall detail the field wiring necessary and typical wiring termination details for all devices.

1.3 AT PROJECT COMPLETION

- A. Prior to final acceptance, provide drawings showing cable numbers and construction details in accordance with the actual system installation. Revise shop drawings to represent actual installation conditions. Drawings shall be in AutoCAD format.
- B. Prior to final acceptance, provide 6 complete sets of operation and maintenance manuals for the system.

1.4 APPROVALS

- A. The system provided shall be approved for use under the following regulatory standards. Include documentation of these approvals as a part of the submittal process.
 - 1. UL 294 - Access Control System Units.
 - 2. Local and State Building Code.

1.5 CONTRACTOR QUALIFICATIONS

- A. The contractor must have regularly engaged in the furnishing and installation of commercial and industrial low voltage systems and related access control systems for a period of at least the last three (3) years and be able to show evidence of successfully completing at least three (3) projects of similar size and scope.
- B. The Contractor shall hold a Class A Contractors License acceptable as valid in The State of Virginia, and have employees in compliance with the Virginia Department of Criminal Justice Services Sections 9-182 and 9-183.
- C. Technically capable and factory trained service personnel at a contractor-owned service facility within 50 miles radius of the project site to provide routine and emergency service for all products used in the project.

PART 2 - PRODUCTS

2.1 FRONT END SYSTEM

- A. The master file server station shall be IBM-compatible desktop (full-size) personal computers (PCs). Provide server per manufacturer minimum requirements.
- B. Communication Ports
 - 1. The computer shall have two serial communication ports. If additional ports are required, they shall be provided by installing additional compatible multi-port cards.

2.2 CARD ACCESS READER

- A. Card Readers: System card reader specifications shall meet the following options:

The system shall support the use of a uni-directional proximity card reader. The card reader shall have a read range of up to 4 inches. The reader shall be able to be mounted

with its sides against metal door or window frames. The reader shall be powered by +12VDC regulated power. The reader shall meet the following specifications:

1. Electrical: Voltage: +12 VDC nominal voltage (5-16 volts)
Current: Less than 100 mA
2. Environmental: Outdoor Operating Temperature: -25 to 145° F (-31 to 63° C)

The card reader shall be the HID ProxPro for standard applications and the HID Miniprox for exterior door mullion mounts where necessary.

2.3 SYSTEM CONTROLLER

- A. Intelligent Controller: To link the security management system software to all other field hardware components (card reader modules and input and output control modules). The controller shall provide full distributed processing of access control and alarm monitoring operations. Access levels, hardware configurations, and programmed alarm outputs assigned at the main server shall be downloaded to the controller, which shall store the information and function using its high-speed, local 32-bit microprocessor. All access granted/denied decisions shall be made at the controller to provide fast responses to card reader transactions.
 1. Offline Operation: In the event that the controller loses communication with system software, it shall continue to function normally (stand-alone). While in this offline state, the controller shall make access granted/denied decisions and maintain a log of the events that occur. Events shall be stored in local memory and uploaded to the system software after communications are restored.

2.4 READER INTERFACE MODULE

- A. Provide interface modules for each access door shown. Ensure compatibility with readers. Interface door contacts, to this module for door position status.
- B. Single Reader Module: The single reader module shall provide an interface between the controller and the card readers. The single reader module shall operate with any card reader that produces a standard Wiegand (Data 1/Data 0) or Clock and Data communication output. The following requirements shall also apply:
 1. The card reader may be up to 500 feet from the single reader module.
 2. Up to eight (8) unique card formats shall be supported.
 3. The single reader module shall support an integrated card reader.
 4. The single reader module shall support three access modes upon loss of communication with the controller.

These modes shall be:

- a. Locked
- b. Unlocked

c. Facility code

5. Input power shall be 12VDC $\pm$ 15%@ 175 mA with an operating range of 10 VDC to 14VDC

2.5 DOOR LOCK POWER SUPPLY

A. Provide power supply with the following features:

1. 120 VAC input
2. 24 VDC output
3. 2 amp minimum output
4. 6 hour battery backup minimum

2.6 REQUEST TO EXIT MOTION SENSOR

A. Provide request to exit motion sensor above door to interface with controller to provide free egress from the space. Unit shall operate on 12 VDC and provide dry form C relay output to interface module.

2.7 CARD PRINTER

A. Access control system software shall support any printer with industry standard and Microsoft certified Windows 2000/2003/XP drivers. System shall support double sided full color printing, edge to edge printing, high speed printing, holographic overlays, in-line magnetic strips coding, in-line smart card encoding (printer model specific).

2.8 USB IMAGE CAPTURE KIT

A. Provide a high resolution CCD (NTSC or PAL) camera with software zoom capabilities, a fully-synchronized cool white built-in flash, a tripod system with a powered base, TWAIN-compliant software, a USB communication cable and a universal power cable. The camera is USB 2.0-compliant, producing high resolution live video for image capture.

2.9 POWER QUALITY

- A. Where required, provide 120 VAC, 60 Hz power from nearest electrical panel, through a junction box, to the system device.
- B. Test for ground loops that may result from use of different power sources for various components.
- C. Provide point of use UPS power unit for the server sized to support the PC, monitor and attached peripherals, including modems and printers in the event of a building power supply failure of up to 1 hour.

2.10 WIRE

A. Provide wire per manufacturers recommendations.

- B. Provide all wiring from devices at doors to the box above the door in conduit. Wiring from above the door may be run outside of conduit provided that it is properly supported (not by ceiling support beams, trusses, or guy wires) at a minimum of every 4 feet. Examples of proper support includes J-hooks and cable tray. If method is different from these, submit this method to engineer prior to installation for approval.

2.11 IDENTIFICATION AND TAGGING

- A. All cables, wires, wiring forms, terminal blocks, and terminals shall be identified by labels, tags, or other permanent markings. The markings shall clearly indicate the function, source, and destination of all cabling, wiring and terminals. All cables and wires shall be identified, utilizing heat-shrunk, pre-printed, wire markers.
- B. All terminal points shall be appropriately labeled.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Install, make fully operational, and test the system as indicated both on the drawings and in this specification.
- B. All necessary back-boxes, pull-boxes, connectors, supports, conduit, cable, and wire shall be furnished and installed to provide a complete and reliable system.
- C. Install conduit, cable, and wire parallel and square with building lines, including raised floor areas. Conduit fill shall not exceed forty (40) percent.

3.2 The access control system shall be installed in strict accordance with manufacturer's recommendations.

3.3 Cables shall be installed completely concealed above ceilings and in walls in accordance with industry standards. The installer must coordinate with the mechanical drawings to compensate for any areas which have plenum ceilings. In any case where there are plenum ceilings, plenum cable will be required.

3.4 System shall be checked-out and tested for proper operation by technicians skilled in access control systems and who are regularly engaged in their installation and commissioning.

3.5 WARRANTY SERVICE

- A. Contractor to warranty the entire system for a minimum of one year, to the extent detailed below.
- B. The contractor shall employ a factory-trained service organization within 100 miles of the job site. This organization shall have a minimum of five (5) years' experience in servicing integrated access control and alarm monitoring systems and equipment.
- C. Fully qualified (factory trained with certification) repair and maintenance personnel shall be expected to be dispatched at all times for any service, maintenance or training call. Untrained or uncertified technicians are unacceptable.

- D. Normal service shall be defined as minor repairs and/or adjustments. Service of this nature shall be provided at no cost to the Owner during normal business hours, which are between 8:00 AM and 5:00 PM, Monday through Friday. For service calls requested by phone before 11:00 AM on a weekday, service shall occur on a same-day basis.
- E. Emergency service shall be required for emergencies defined as critical equipment not being functional, and shall be furnished at no cost to the Owner. Emergency service shall respond within a four (4) hour period, twenty-four (24) hours per day, three hundred and sixty-five (365) days a year.

PART 4 - TRAINING

- 4.1 Provide a minimum of (2) hours training for the Owner. Training sessions to be determined by the owner.

END OF ACCESS CONTROL / VIDEO BADGING SYSTEM

SECTION 16780
WIRELESS CLOCK SYSTEM

PART 1 – GENERAL

1.1 SECTION INCLUDES

- A. Transmission System
 - 1. System Controller with Receiver (GPS, CDMA, Ethernet)
 - 2. Primary Internal Transmitter
 - 3. Primary External Transmitter
- B. Wireless Synchronized Devices
 - 1. Digital Clock
 - 2. Elapsed Time Indicator
 - 3. Master Clock Synchronizer
 - 4. Other

1.2 RELATED DIVISIONS AND SECTIONS

- A. Division 26 00 00 - Electrical 120V for 60Hz grounded outlet required for System Master.
- B. Division 26 00 00 - Electrical 120V for 60Hz grounded outlet required for external transmitter
- C. Division 26 00 00 - Electrical 120V for 60Hz grounded outlet for each AC powered clock, Computer Time Synchronizer and Master Clock Synchronizer and other components

1.3 REFERENCES

- A. National Fire Protection Agency (NFPA) – 70, National Electric Code 2005

1.4 DEFINITIONS

- A. (GPS): Global Positioning System A worldwide system that employs 24 orbiting satellites in an integrated network to determine geographic location anywhere in the world, and which employs and transmits atomic time.
- B. (CDMA): Code Division Multiple Access A time synchronization used in the mobile telephone industry.
- C. Ethernet: Provides time synchronization via SNTP (Simple Network Time Protocol) or Daytime Protocol from time server.

1.5 SUBMITTALS

- A. Product Data: Submit complete catalog data for each component, describing physical characteristics and method of installation. Submit brochure showing available colors and finishes of clocks.
- B. Operating License (if required): Submit evidence of application for operating license prior to installing equipment. Furnish the license, or if the license has not been received, a copy of the application for the license, to the Owner prior to operating the equipment. When license is received, deliver original license to Owner.
- C. Samples: Submit one clock for approval. Approved sample shall be tagged and shall be installed in the work at location directed.
- D. Manufacturer's Instructions: Submit complete installation, set-up and maintenance instructions.

1.6 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer: Company specializing in manufacturing commercial timekeeping systems with a minimum of 10 continuous years of documented experience.
 - 2. Installer: Company with documented experience in the installation of commercial timekeeping systems.

1.7 REGULATORY REQUIREMENTS

- A. Equipment and components furnished shall be of manufacturer's latest model.
- B. System Controller, Transmitter and receiver shall comply with Part 90 of FCC rules, as follows:
 - 1. This device may not cause harmful interference.
 - 2. Transmitter frequency shall be governed by FCC Part 90.35.
 - 3. Transmitter output power shall be governed by FCC Parts 90 and 74.
- C. System shall be installed in compliance with local and state authorities having jurisdiction.
- D. Permits: Obtain operating license for the transmitter from the FCC. (FCC licensing can be coordinated by system manufacturer)

1.8 DELIVERY, STORAGE AND HANDLING

- A. Deliver all components to the site in the manufacturer's original packaging. Packaging shall contain manufacturer's name and address, product identification number, and other related information.
- B. Store equipment in finished building, unopened containers until ready for installation.

1.9 FIELD CONDITIONS

- A. Clocks shall not be installed until painting and other finish work in each room is complete.
- B. Coordinate installation of GPS receiver and external antenna for access to the roof or exterior side-wall so that the bracket and related fasteners are watertight.

PART 2 - PRODUCTS

2.1 SYSTEMS DESCRIPTION

- A. A basic wireless timekeeping system, consisting of a system controller, a built-in or external transmitter, transmitter antenna, a means of receiving time synchronization (GPS, CDMA, Ethernet), digital clocks, and accessory or optional components for expanding the system and its operations, that is capable of synchronizing clocks and computers throughout the facility on a daily basis.
- B. System shall synchronize all clocks to each other. System shall utilize GPS, CDMA, or Ethernet technology to provide atomic time to components. System shall not require hard wiring for its components except for AC power. Clocks shall automatically adjust for Daylight Saving Time per the Daylight Saving time settings in the system controller.
- C. The system shall include an internal real time clock reference so that failure of the GPS signal shall not cause the clocks to fail in indicating the correct time.
- D. The system shall incorporate a "fail-proof" design so that a temporary power interruption shall not cause failure of the system. Upon restoration of power, the system shall resume normal operation.
- E. The system shall include a optional notification pager or communication method to notify a local supervisor or maintenance personnel when the pager is active and the master is transmitting to verify signal reception.
- F. System instruction manual and equipment shall be available for building site transmitter signal reception diagnosis.

2.2 MANUFACTURER

- A. Wireless timekeeping system and its components shall be manufactured by American Time & Signal Company or approved equal.

2.3 EQUIPMENT

- A. Wireless system controller: The system controller encoder shall incorporate a display and a keypad to provide the following features:
 - 1. Time zone selection via the keypad and display for all USA time zones as well as others requiring programming by American Time and Signal. Includes all US time zones: Eastern, Central, Mountain, Pacific, Alaska and Hawaii.
 - 2. Automatic Daylight Saving Time Adjustment can be enabled or disabled from keypad.

3. GPS interface and real time GPS status display mode.
 4. Password protected Administrator Menu to set the date, local time zone, clock addresses, and other system parameters as needed.
 5. Database programming and administration using its keypad and LCD display
 6. The system controller shall contain an internal clock such that failure of reception from the GPS will not disable the operation of the clocks.
- B. GPS Receiver: GPS roof receiver with 10' cable attached (optional length extension cable available: 50', and 100' or specified). The GPS Receiver shall be a complete GPS receiver with a built-in antenna, designed for roof or outdoor mounting. Provide mounting bracket for attachment to roof structure, CDMA antenna or connector for Ethernet synchronization.
- C. Transmitter: Wireless transmitters may be internal or external, up to 350 Watts. The transmitter parameters shall be:
1. Frequency Range: multiple frequencies acceptable but are specific to manufacturer
 2. Transmitter output power: Internal 1 - 5 Watt or External 10-350 Watt in external case
 3. Transmission Range: Up to 50 miles radius (transmitter dependent)
 4. Radio technology: Narrowband FM, 12.5 KHz bandwidth
 5. Transmission format: POCSAG, digital one-way communication
 6. Digital Data rate: 512 - 2400BPS
 7. Operating range: 0 degrees C. to 70 degrees
- D. Antenna: shall be for indoor or outdoor applications. Antenna polarization shall be dependent on manufacturer's recommendation.
- E. Power supply: (included with master),
1. Input: 120-volt AC 50/60 Hz
 2. Output: 12-volt DC, 3 Amps
 3. Other
- F. Recommended (but optional) Surge Protector/Battery Backup:
1. Input: 120-volt AC 60 Hz +/- 1 Hz.
 2. Output: 120-volt AC, 550VA, 300 watts
 3. Surge Energy Rating: 700 joules with 10x1000uS pulse

- G. Digital Clocks (require line voltage to illuminate digits)

2.4 SUBSTITUTION LIMITATIONS

- A. Proposed substitutions, to be considered, shall be manufactured of equivalent materials that meet or exceed specified requirements of this Section.
- B. Other systems requiring wiring and/or conduit between system controller and clocks will not be acceptable.

2.5 SYSTEM OPERATION AND STARTUP SEQUENCE

- A. System shall receive Atomic Time information from GPS, CDMA or Ethernet that is connected to the system controller. The system controller is a powerful multi-tasking device that is capable of sending accurate time information to synchronize all the system wireless clocks and accessories. The system can be monitored and programmed from the system controller keypad and LCD.
- B. Wireless System Controller Operation
 - 1. When power is first applied to the system controller, it checks for and displays the software version and looks for the GPS time signal. Once the system controller has received the GPS time, it sets its internal clock to that time. The system controller then starts to transmit its internal time according to the specified time synchronization mode. The system controller updates its internal clock every time it receives valid time data from the GPS receiver.
- C. Digital Clock Operation
 - 1. Connect the DC adapter (supplied with each digital clock) to the appropriate power source. Select the display mode (12 or 24 hours) and the brightness level using the switches in the back of the clock. There is no need for any additional adjustment.
 - 2. After several seconds of initial setup, the clock receiver will look for a valid time transmission and synchronize to the system controller.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that construction is complete in spaces to receive equipment and that rooms are clean and dry.
- B. Verify that 120-volt electrical outlet is located within 6 feet of location of transmitter and the outlet is operational and properly grounded.
- C. Verify that all 120-volt electrical outlets for the AC powered clocks are located at the exact installation point and the outlet is operational and properly grounded.

3.2 FIELD INSPECTION

- A. Prior to final acceptance, inspect each system component to function properly and replace parts that are found defective.

3.3 MANUFACTURER SERVICES

- A. If needed, provide technical assistance as demonstrated in the manufacturer's system user guide, on product start up and system setup, to owners or installers representatives via phone, fax, or e-mail.

3.4 SYSTEM INSTALLATION

- A. Install in accordance with manufacturer's installation manual furnished with the system, for proper installation of each system component.

3.5 CLEANING

- A. Prior to final acceptance, clean exposed surfaces of all system components, using cleaning methods recommended by the manufacturer.

END OF WIRELESS CLOCK SYSTEM